2022 Enrollment

Course List and Summary

Master's Degree Program

開講授業科目表(MC)　Opening of a course class subject list

機械機能創成専攻
Department of Mechanical Systems Engineering

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門基盤科目 Major Basic Subjects	数値解析学	毎年 Every year	J		2		左記の専門基盤科目の内から4科目以上選択履修し，8単位以上修得すること. A student has to earn 8 or more credits from the Major basic subjects listed in the left column.
	Numerical Analysis	隔年 Every second year	E				
	確率モデル論 Probability Models	毎年 Every year	JE		2		
	基盤流体力学	毎年 Every year	J		2		
	Fluid Dynamics	毎年 Every year	E				
	固体力学	毎年 Every year	J		2		
	Solid Mechanics	毎年 Every year	E				
	熱科学・工学A	隔年 Every second year	J		2		
	Thermal Science and Engineering A	隔年 Every second year	E				
	熱科学・工学B	隔年 Every second year	J		2		
	Thermal Science and Engineering B	隔年 Every second year	E				
	システム制御工学Ⅰ System Control Engineering Ⅰ	毎年 Every year	E		2		
	システム制御工学Ⅱ System Control Engineering Ⅱ	毎年 Every year	E		2		
	材料化学 Materials Chemistry	毎年 Every year	E		2		
	計算機科学	隔年 Every second year	J		2		
	Computer Hardware Fundamentals	隔年 Every second year	E				
	固体物理学 Solid State Physics	毎年 Every year	E		2		
	塑性力学 Mechanics of Plasticity	毎年 Every year	E		2		
	生物の構造と機能	隔年 Every second year	J		2		
	Structure and Function Living System	隔年 Every second year	E				
	ロボットビジョン	隔年 Every second year	J		2		
	Robot Vision	隔年 Every second year	E				
	ディジタル信号処理	隔年 Every second year	J		2		
	Digital Signal Processing	隔年 Every second year	E				
	力学と物理数学	隔年 Every second year	J		2		
	Introduction to Classical Mechanics and Physical Mathematics	隔年 Every second year	E				
	連続体力学	隔年 Every second year	J		2		
	Continuum Mechanics	隔年 Every second year	E				
	応用流体力学	隔年 Every second year	J		2		
	Applied Fluid Mechanics	隔年 Every second year	E				
	構造力学	隔年 Every second year	J		2		
	Structural Mechanics	隔年 Every second year	E				

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				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	知的機械設計学 Intelligent Machine Design				2		左記の専門科目の内から少なくても1科目以上選択履修し2単位以上を修得するとともに，左記の科目，特別講義A，特別研修A，及び関連科目を選択履修し，全体で12単位以上を修得すること．ただし，特別講義A，特別研修Aで修得した単位は2単位まで本要件に含めることができる．なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる． A student has to earn 2 or more credits from the major general subjects listed in the left colum. In addition, 12 or more credits in total are required to earn from the Major general subjects, Advanced seminar A, Special lecture A, and related subjects offered by other departments. However, a total of 2 credits at most, obtained from Advanced seminar A and Special lecture A, is included in this requirement. As an exception, a total of 8 credits obtained from Special lecture A is included in this requirement, when a student is enrolled in our double-dgree program or joint educationnal program.
	ナノ・マイクロトライボロジー	隔年 Every second year	J		2		
	Nano/Micro Tribology	隔年 Every second year	E				
	微小機械構成学 Micro-Nanomechanical Architectonics	隔年 Every second year	E		2		
	エネルギーシステム学 Energy Systems Engineering	隔年 Every second year	E		2		
	環境強度システムデザイン学	隔年 Every second year	J		2		
	Oxidation in High Temperature Environments of Structures and Materials	隔年 Every second year	E				
	機能性流体工学 Functional Fluids Engineering	隔年 Every second year	E		2		
	機械システム保全学 Mechanical Systems Maintenance Engineering	隔年 Every second year	E		2		
	固体イオニクス論 Introduction to Solid State Ionics	隔年 Every second year	E		2		
	超精密加工学	隔年 Every second year	J		2		
	Ultraprecision Machining	隔年 Every second year	E				
	精密生産システム学 Manufacturing Systems	毎年 Every year	J		2		
	地殻システム設計学	隔年 Every second year	J		2		
	Earth Systems Design	隔年 Every second year	E				
	ニューロモルフィックデバイス工学	隔年 Every second year	J		2		
	Neuromorphic Device Engineering	隔年 Every second year	E				
	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境行政論 Environmental Administration	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	毎年 Every year	JE		2		
	インターンシップ研修 Internship Training				1～2		
	国際学術インターンシップ研修 International Scientific Internship Training				1～2		
	機械機能創成特別講義A Special Lecture on Mechanical Systems Engineering A				1～2		
	機械機能創成特別研修A Advanced Seminar on Mechanical Systems Engineering A				1～2		
関連科目 Related Subjects of Other Majors	本研究科委員会において関連科目として認められたもの。 Those approved by the Educational Committee of the Graduate School of Engineering						
専門科目 Major General Subjects	機能システム学セミナー Seminar on Mechanical Systems	毎年 Every year	JE		2		左記のセミナーのいずれかを履修し，2単位を修得すること． A student has to earn 2 credits from one of the seminar listed in the left column.
	エネルギー学セミナー Seminar on Energy Systems Engineering	毎年 Every year	JE		2		
	知的メカノシステム工学セミナー Seminar on Intelligent Mechano-Systems	毎年 Every year	JE		2		

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				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	機械機能創成修士研修 Master's Thesis Research in Mechanical Systems and Engineering			8			

1. 上記科目の単位数を合わせて30単位以上を修得すること。(Students must acquire 30 or more credits from the subjects above.)
2. 『開講時期』については、現時点におけるものであり、変更になることもある。開講年度等は授業時間割等で確認すること。
   "Class Schedule" is currently tentative and may be subject to change.
   Make sure to check the fiscal years when each class is offered with the time schedule of the classes, program syllabus, etc.
3. 『使用言語』欄のアルファベット記号について (Language key)
   E:英語開講科目(Lectures given in English)
   JE:準英語開講科目(Lectures given in Japanese, with English explanations)
   J:日本語開講科目(Lectures given in Japanese)

Numerical Analysis 2 credits

Elective Required
Professor Naofumi Ohnishi

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.

Probability Models 2 credits

Elective Required
Associate Professor Reika Fukuizumi

Mathematical analysis is important for the understanding of random phenomenon appearing 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 Masaya Shigeta

Students acquire the intuition and knowledge of the nature of fluid motion by studying the fundamentals of Fluid Dynamics with not only theories but also visualized images, observation videos, and computer graphic animations. The goal is for students to be able to predict the fluid motion and to design the control methods in aerodynamic and material processing applications.
Keywords: Vortex, Convection, Stream/Path/Streak lines, Incompressibility/Compressibility, Conservation laws, Bernoulli's theorem, Viscosity and diffusivity, Boundary layer, Aerodynamic force, Laws of similarity, Reynolds number, Strouhal number and Kármán's vortex street, Analogy with heat and mass transfers, Navier-Stokes and wave equations.

Solid Mechanics 2 credits

Elective Required
Associate Professor Yoshiteru Aoyagi

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 A 2 credits

Elective Required
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Professor Takashi Tokumasu
Associate Professor Hisashi Nakamura

In this course, students will master the basic physics of reactive flows in thermal fluid science. In particular, the course is designed to cover flame behaviors and peculiar phenomena in laminar and turbulent combustion, the basic concept of chemical kinetics and the understanding of reaction phenomena of electrochemistry on the standpoint of thermal science.Through the class, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

Thermal Science and Engineering B 2 credits

Elective Required
Professor Taku Ohara
Professor Tetsushi Biwa
Professor Atsuki Komiya
Associate Professor Gota Kikugawa

The students will master the basic physics of thermal energy conversion and heat transfer in both micro and macroscopic scales, and learn to link this knowledge to engineering applications. More specifically, the series lectures: i) the Molecular Dynamics and molecular-scale analyses of thermo-fluid phenomena, ii) oscillating-flow based heat transfer and energy conversion, iii) visualization and control of multi-scale heat and mass transfer, and iv) statistical mechanics regarding interface phenomena will be done. Students are expected to further deepen their understanding of the essence of thermal phenomena.

System Control Engineering I 2 credits

Elective Required
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.

System Control Engineering II 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Yusuke Tamura

This course gives an advanced lecture based on the contents of "System Control Engineering I." This lecture introduces the analysis and design methods of control systems used for designing motion control for increasingly advanced and complex mechanical systems. Students will learn fundamental concepts for state and output feedback in the state space, state observer and Kalman filter, and response analysis of control systems. This class includes some exercises using MATLAB.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
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 a lecture and practice 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
Professor Hiroyuki Takizawa

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 mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Professor Makoto Ohta
Professor Takuji Ishikawa

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.

Robot Vision 2 credits

Elective Required
Professor Takayuki Okatani

This course explains various problems and their solutions in computer vision. The problems are basically inverse-problems in which we wish to estimate some information about an object or a scene from their image(s), such as the three-dimensional shape of a scene or the categories of object. Students will first learn a series of fundamental concepts, and then study a number of approaches to the problems of computer vision, where the main focus is on the recently developed deep learning methods.

Digital Signal Processing 2 credits

Elective Required
Associate Professor Shingo Kagami
Associate Professor Toshinori Kuwahara

This lecture covers fundamentals of digital signal processing that provides a foundation for sensing, control, communication, voice processing, image processing, and so forth. Related subjects include discrete-time signals, discrete-time and discrete Fourier transformations, sampling, digital frequency analysis, discrete-time systems, z transformation, digital filtering, and some more advanced topics.

Introduction to Mechanics and Physical Mathematics 2 credits

Elective Required
Professor Tomonaga Okabe

In the modeling of classical mechanics, we often meet the applied mathematics, such as differential geometry or manifolds theory. These have been developed from the viewpoint of mathematical universality and do not always provide new ideas directly. But, we often need such a background to make the theoretical models. Furthermore, symbols and calculations developed in these fields are not commonly used by general engineering students or graduate students of engineering, and this is considered to be an obstacle for learning them. In this lecture, I am going to introduce those mathematical expressions as simple as possible, so that the students can employ the advanced mathematics in the general mechanical engineering field. This course can also be considered as an introduction to the tools of physical mathematics.

Continuum Mechanics 2 credits

Elective Required
Professor Takuji Ishikawa

Materials may be regarded as continuum at the macroscopic scale. In this lecture, we aim to mathematically understand the motion and deformation of materials, such as solid and fluid, at the macroscopic scale. We first explain the concepts of continuum and stress as well as vector/tensor analysis. We then derive basic equations describing the motion and deformation of continuum, such as equilibrium equation, constitutive equation and boundary conditions. This lecture is the basis of solid and fluid mechanics, which is recommended to students who want to establish a whole picture of both subjects.

Applied Fluid Mechanics 2 credits

Elective Required
Professor Jun Ishimoto
Professor Yuka Iga

This lecture will be given on the fundamentals and applications of multiphase fluid dynamics and numerical analysis related to the fluid dynamic phenomena with heterogeneous interfaces, gas-liquid two-phase flow, phase change, cavitation, and the fundamentals of turbo-type fluid machinery such as pumps and turbines. The main topics to be understand are as follows. 1) Flow pattern and classification method of gas-liquid two-phase flow, 2) Fundamentals of two-fluid model, 3) Modeling of dispersed multi-phase flow and numerical analysis, 4) Modeling of liquid atomization 5) Classification and role of fluid machinery 6) Generation of cavitation in pumps.

Structural Mechanics 2 credits

Elective Required
Professor Kanjuro Makihara

This lecture gives a fundamental knowledge on the structural analysis and the structural design of mechanical structures. Main topics of this lecture are deformation and stress analyses of fuselage and wing structures subjected to bending, twisting and shear. (1) Fundamental of mechanical structure and material strength. (2) Vibration analysis for structures. (3) Applied load and stress analysis of mechanical structures. (4) Structural identification and structural health monitoring (5) Structural mechanics for aerospace engineering.

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.

Energy Systems Engineering 2 credits

Elective Required
Professor Hiroo Yugami

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
Associate Professor Ken Suzuki

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.

Functional Fluids Engineering 2 credits

Elective Required
Professor Takehiko Sato
Professor Masaya Shigeta
Professor Hidemasa Takana

This course covers fluids that express functionality depending by external fields. We discuss fundamentals of fluids’ structure, mechanism of exhibiting the functionalities, transport phenomena, governing equations, and diagnostic method for the functional fluids such as plasma fluid, magnetic fluid, MR or ER fluids, ionic liquid. Also, regarding advanced applications using functionalities of those fluids, we outline plasma medicine, environmental remediation, material processing, energy equipment and other topics.

Mechanical Systems Maintenance Engineering 2 credits

Elective Required
Professor Tetsuya Uchimoto

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 outline the disciplines composing maintenance engineering such as reliability engineering, materials degradation, risk evaluation, nondestructive testing, failure analysis. In addition, recent works will be introduced: such as a novel health monitoring system, a vibration control system, and so on.

Introduction to Solid State Ionics 2 credits

Elective Required
Professor Koji Amezawa
Associate Professor Takashi Nakamura

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
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. The purpose of this course, especially, is to deepen understanding of Ultra-precision machining technology focusing on micro-mechanical machining, non-conventional processing or additive manufacturing.

Manufacturing Systems 2 credits

Elective Required
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.

Earth Systems Design 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.

Neuromorphic Device Engineering 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 point of view of signal processing systems beyond the present computing, we will review brain and nervous systems. The students will be able to:
・Understand the detail structures and functions of neurons as a basic neural element.
・Learn about neuromorphic devices and system integration concept/technology.
1st. Introduction & elements of nervous systems
2nd. Neuronal potential and nervous excitement
3rd. Mechanism of synapse transmission
4th. Sensory systems
5th. Neural network
6th. Special talk
7th. Neuromorphic devices 1
8th. Neuromorphic devices 2
9th. Neuromorphic system integration 1
10th. Neuromorphic system integration 2
11th. Neuromorphic system integration 3
12th. Special talk

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 Administration 2 credits

Elective Required Various teachers

The Graduate School of Environmental Studies has had a cooperation agreement with Miyagi Prefecture and Sendai City, respectively.
In this lecture, students learn about current status and issues related to environmental policies of Miyagi Prefecture and Sendai City (about climate change such as global warming, promotion of waste reduction and recycling including plastic recycling, and environment-related laws) to achieve environmental conservation and sustainable society, and learn about environmental policies and environmental technologies.
In addition to lectures, this course can help students acquire practical knowledge and develop their ability to think about how to respond to environmental issues through exercise and facility tour.

Ethics of Engineering and Life 2 credits

Elective Required
Professor Tetsutaro Hattori

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 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.

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
1 or 2 credits

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.

Special Seminar on Mechanical Systems Engineering A
1 or 2 credits

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 Takahito Ono
Professor Kazuhiro Ogawa
Professor Toshiyuki Hashida
Professor Tetsu Tanaka
Associate Professor Masayoshi Mizutani
Associate Professor Masaya Toda
Associate Professor Kazuhisa Sato
Associate Professor Takafumi Fukushima
Associate Professor Yuji Ichikawa

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 Tetsushi Biwa
Professor Masaya Shigeta
Professor Kaoru Maruta
Professor Tetsuya Uchimoto
Professor Yuka Iga
Professor Koji Amezawa
Professor Atsuki Komiya
Professor Hidemasa Takana
Associate Professor Hisashi Nakamura
Associate Professor Takashi Nakamura

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.

Master's Thesis Research in Mechanical Systems and Engineering 8 credits

Required Various teachers

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.

開講授業科目表(MC)　Opening of a course class subject list

ファインメカニクス専攻
Department of Finemechanics

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門基盤科目 Major Basic Subjects	数値解析学	毎年 Every year	J		2		左記の専門基盤科目の内から4科目以上選択履修し，8単位以上修得すること. A student has to earn 8 or more credits from the Major basic subjects listed in the left column.
	Numerical Analysis	隔年 Every second year	E				
	確率モデル論 Probability Models	毎年 Every year	JE		2		
	基盤流体力学	毎年 Every year	J		2		
	Fluid Dynamics	毎年 Every year	E				
	固体力学	毎年 Every year	J		2		
	Solid Mechanics	毎年 Every year	E				
	熱科学・工学A	隔年 Every second year	J		2		
	Thermal Science and Engineering A	隔年 Every second year	E				
	熱科学・工学B	隔年 Every second year	J		2		
	Thermal Science and Engineering B	隔年 Every second year	E				
	システム制御工学Ⅰ System Control Engineering Ⅰ	毎年 Every year	E		2		
	システム制御工学Ⅱ System Control Engineering Ⅱ	毎年 Every year	E		2		
	材料化学 Materials Chemistry	毎年 Every year	E		2		
	計算機科学	隔年 Every second year	J		2		
	Computer Hardware Fundamentals	隔年 Every second year	E				
	固体物理学 Solid State Physics	毎年 Every year	E		2		
	塑性力学 Mechanics of Plasticity	毎年 Every year	E		2		
	生物の構造と機能	隔年 Every second year	J		2		
	Structure and Function of Living System	隔年 Every second year	E				
	ロボットビジョン	隔年 Every second year	J		2		
	Robot Vision	隔年 Every second year	E				
	ディジタル信号処理	隔年 Every second year	J		2		
	Digital Signal Processing	隔年 Every second year	E				
	力学と物理数学	隔年 Every second year	J		2		
	Introduction to Classical Mechanics and Physical Mathematics	隔年 Every second year	E				
	連続体力学	隔年 Every second year	J		2		
	Continuum Mechanics	隔年 Every second year	E				
	応用流体力学	隔年 Every second year	J		2		
	Applied Fluid Mechanics	隔年 Every second year	E				
	構造力学	隔年 Every second year	J		2		
	Structural Mechanics	隔年 Every second year	E				

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				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	光計測 Optical Metrology	隔年 Every second year	E		2		左記の専門科目の内から少なくても1科目以上選択履修し2単位以上を修得するとともに，左記の科目，特別講義A，特別研修A，及び関連科目を選択履修し，全体で12単位以上を修得すること．ただし，特別講義A，特別研修Aで修得した単位は2単位まで本要件に含めることができる．なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる． A student has to earn 2 or more credits from the major general subjects listed in the left colum. In addition, 12 or more credits in total are required to earn from the Major general subjects, Advanced seminar A, Special lecture A, and related subjects offered by other departments. However, a total of 2 credits at most, obtained from Advanced seminar A and Special lecture A, is included in this requirement. As an exception, a total of 8 credits obtained from Special lecture A is included in this requirement, when a student is enrolled in our double-dgree program or joint educationnal program.
	材料システム計測評価学	隔年 Every second year	J		2		
	Sensing and Evaluation of Materials System	隔年 Every second year	E				
	超精密加工学	隔年 Every second year	J		2		
	Ultraprecision Machining	隔年 Every second year	E				
	ナノ・マイクロメカノプティクス Nano/Micro Mechanoptics	隔年 Every second year	E		2		
	ナノ・マイクロトライボロジー	隔年 Every second year	J		2		
	Nano/Micro Tribology	隔年 Every second year	E				
	微小破壊学	毎年 Every year	J		2		
	Strength and Reliability of Advanced Materials and Devices	毎年 Every year	E				
	グリーンナノテクノロジー Green Nanotechnology	隔年 Every second year	E		2		
	地殻構造・エネルギー工学 Geo-technical and Energy Engineering	隔年 Every second year	JE		2		
	精密生産システム学 Manufacturing Systems	毎年 Every year	J		2		
	材料システム設計学	隔年 Every second year	J		2		
	Design of Materials System	隔年 Every second year	E				
	バイオセンサ工学 Biosensor Engineering	隔年 Every second year	E		2		
	バイオマイクロマシン工学 Bio-Micromachine Engineering	隔年 Every second year	E		2		
	生物流体工学	隔年 Every second year	J		2		
	Biofluid Mechanics	隔年 Every second year	E				
	バイオメカニクス特別講義Ⅰ	隔年 Every second year	J		2		
	Special Lecture Series on Integrated Biomechanics Ⅰ	隔年 Every second year	E				
	知的メカノシステム解析学 Intelligent Mechanosystem Analysis	隔年 Every second year	E		2		
	表面ナノ・マイクロ計測制御学 Nano-and Micro-Surface Metrogy and Engineering	隔年 Every second year	E		2		
	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境行政論 Environmental Administration	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	毎年 Every year	JE		2		
	インターンシップ研修 Internship Training				1～2		
	国際学術インターンシップ研修 International Scientific Internship Training				1～2		
	ファインメカニクス特別講義A Special Lecture on Finemechanics A				1～2		
	ファインメカニクス特別研修A Advanced Seminar on Finemechanics A				1～2		
関連科目 Related Subjects of Other Majors	本研究科委員会において関連科目として認められたもの。 Those approved by the Educational Committee of the Graduate School of Engineering						

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Department of Finemechanics

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	材料メカニクスセミナー Seminar on Materials and Mechanics	毎年 Every year	JE		2		左記のセミナーのいずれかを履修し，2単位を修得すること. A student has to earn 2 credits from one of the seminar listed in the left column.
	ナノメカニクスセミナー Seminar on Nanomechanics	毎年 Every year	JE		2		
	バイオメカニクスセミナー Seminar on Biomechanics	毎年 Every year	JE		2		
	知的メカノシステム工学セミナー Seminar on Intelligent Mechano-Systems	毎年 Every year	JE		2		
専門科目 Major General Subjects	ファインメカニクス修士研修 Master's Thesis Research in Finemechanics			8			

1．上記科目の単位数を合わせて30単位以上を修得すること。(Students must acquire 30 or more credits from the subjects above.)
2．『開講時期』については、現時点におけるものであり、変更になることもある。開講年度等は授業時間割等で確認すること。
"Class Schedule" is currently tentative and may be subject to change.
Make sure to check the fiscal years when each class is offered with the time schedule of the classes, program syllabus, etc.
3．『使用言語』欄のアルファベット記号について (Language key)
E：英語開講科目(Lectures given in English)
JE：準英語開講科目(Lectures given in Japanese, with English explanations)
J：日本語開講科目(Lectures given in Japanese)

Numerical Analysis 2 credits

Elective Required
Professor Naofumi Ohnishi

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.

Probability Models 2 credits

Elective Required
Associate Professor Reika Fukuizumi

Mathematical analysis is important for the understanding of random phenomenon appearing 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 Masaya Shigeta

Students acquire the intuition and knowledge of the nature of fluid motion by studying the fundamentals of Fluid Dynamics with not only theories but also visualized images, observation videos, and computer graphic animations. The goal is for students to be able to predict the fluid motion and to design the control methods in aerodynamic and material processing applications.
Keywords: Vortex, Convection, Stream/Path/Streak lines, Incompressibility/Compressibility, Conservation laws, Bernoulli's theorem, Viscosity and diffusivity, Boundary layer, Aerodynamic force, Laws of similarity, Reynolds number, Strouhal number and Kármán's vortex street, Analogy with heat and mass transfers, Navier-Stokes and wave equations.

Solid Mechanics 2 credits

Elective Required
Associate Professor Yoshiteru Aoyagi

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 A 2 credits

Elective Required
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Professor Takashi Tokumasu
Associate Professor Hisashi Nakamura

In this course, students will master the basic physics of reactive flows in thermal fluid science. In particular, the course is designed to cover flame behaviors and peculiar phenomena in laminar and turbulent combustion, the basic concept of chemical kinetics and the understanding of reaction phenomena of electrochemistry on the standpoint of thermal science.Through the class, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

Thermal Science and Engineering B 2 credits

Elective Required
Professor Taku Ohara
Professor Tetsushi Biwa
Professor Atsuki Komiya
Associate Professor Gota Kikugawa

The students will master the basic physics of thermal energy conversion and heat transfer in both micro and macroscopic scales, and learn to link this knowledge to engineering applications. More specifically, the series lectures: i) the Molecular Dynamics and molecular-scale analyses of thermo-fluid phenomena, ii) oscillating-flow based heat transfer and energy conversion, iii) visualization and control of multi-scale heat and mass transfer, and iv) statistical mechanics regarding interface phenomena will be done. Students are expected to further deepen their understanding of the essence of thermal phenomena.

System Control Engineering I 2 credits

Elective Required
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. This class includes some exercises using MATLAB.

System Control Engineering II 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Yusuke Tamura

This course gives an advanced lecture based on the contents of "System Control Engineering I." This lecture introduces the analysis and design methods of control systems used for designing motion control for increasingly advanced and complex mechanical systems. Students will learn fundamental concepts for state and output feedback in the state space, state observer and Kalman filter, and response analysis of control systems. This class includes some exercises using MATLAB.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
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 a lecture and practice 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
Professor Hiroyuki Takizawa

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 mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Professor Makoto Ohta
Professor Takuji Ishikawa

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.

Robot Vision 2 credits

Elective Required
Professor Takayuki Okatani

This course explains various problems and their solutions in computer vision. The problems are basically inverse-problems in which we wish to estimate some information about an object or a scene from their image(s), such as the three-dimensional shape of a scene or the categories of object. Students will first learn a series of fundamental concepts, and then study a number of approaches to the problems of computer vision, where the main focus is on the recently developed deep learning methods.

Digital Signal Processing 2 credits

Elective Required
Associate Professor Shingo Kagami
Associate Professor Toshinori Kuwahara

This lecture covers fundamentals of digital signal processing that provides a foundation for sensing, control, communication, voice processing, image processing, and so forth. Related subjects include discrete-time signals, discrete-time and discrete Fourier transformations, sampling, digital frequency analysis, discrete-time systems, z transformation, digital filtering, and some more advanced topics.

Introduction to Classical Mechanics and Physical Mathematics 2 credits

Elective Required
Professor Tomonaga Okabe

In the modeling of classical mechanics, we often meet the applied mathematics, such as differential geometry or manifolds theory. These have been developed from the viewpoint of mathematical universality and do not always provide new ideas directly. But, we often need such a background to make the theoretical models. Furthermore, symbols and calculations developed in these fields are not commonly used by general engineering students or graduate students of engineering, and this is considered to be an obstacle for learning them. In this lecture, I am going to introduce those mathematical expressions as simple as possible, so that the students can employ the advanced mathematics in the general mechanical engineering field. This course can also be considered as an introduction to the tools of physical mathematics.

Continuum Mechanics 2 credits

Elective Required
Professor Takuji Ishikawa

Materials may be regarded as continuum at the macroscopic scale. In this lecture, we aim to mathematically understand the motion and deformation of materials, such as solid and fluid, at the macroscopic scale. We first explain the concepts of continuum and stress as well as vector/tensor analysis. We then derive basic equations describing the motion and deformation of continuum, such as equilibrium equation, constitutive equation and boundary conditions. This lecture is the basis of solid and fluid mechanics, which is recommended to students who want to establish a whole picture of both subjects.

Applied Fluid Mechanics 2 credits

Elective Required
Professor Jun Ishimoto
Professor Yuka Iga

This lecture will be given on the fundamentals and applications of multiphase fluid dynamics and numerical analysis related to the fluid dynamic phenomena with heterogeneous interfaces, gas-liquid two-phase flow, phase change, cavitation, and the fundamentals of turbo-type fluid machinery such as pumps and turbines. The main topics to be understand are as follows. 1) Flow pattern and classification method of gas-liquid two-phase flow, 2) Fundamentals of two-fluid model, 3) Modeling of dispersed multi-phase flow and numerical analysis, 4) Modeling of liquid atomization 5) Classification and role of fluid machinery 6) Generation of cavitation in pumps.

Structural Mechanics 2 credits

Elective Required
Professor Kanjuro Makihara

This lecture gives a fundamental knowledge on the structural analysis and the structural design of mechanical structures. Main topics of this lecture are deformation and stress analyses of fuselage and wing structures subjected to bending, twisting and shear. (1) Fundamental of mechanical structure and material strength. (2) Vibration analysis for structures. (3) Applied load and stress analysis of mechanical structures. (4) Structural identification and structural health monitoring (5) Structural mechanics for aerospace engineering.

Optical Metrology 2 credits

Elective Required
Professor Wei Gao
Associate Professor Hiraku Matsukuma

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.

Sensing and Evaluation of Materials System 2 credits

Elective Required
Professor Hitoshi Soyama
Professor Hironori Tohmyoh

Advanced materials system composed of the variety of materials produces various functions. To operate such a materials system without failure for realizing a safe society, comprehensive understanding of the system, which requires trials not tied to conventional methodologies, is indispensable. In this course, in addition to the error theory, which is the basis of measurement, and the inverse problem analysis for identifying the physical quantities, the evaluation of residual strain, which exists in various devices and structures, is treated. Moreover, the methods for evaluating cracks or material degradation in advanced materials system having various scales from electronic devices to various plants are lectured.

Ultraprecision Machining 2 credits

Elective Required
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. The purpose of this course, especially, is to deepen understanding of Ultra-precision machining technology focusing on micro-mechanical machining, non-conventional processing or additive manufacturing.

Nano/Micro Mechanoptics 2 credits

Elective Required
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

Green Nanotechnology 2 credits

Elective Required
Professor Seiji Samukawa

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.

Geo-technical and Energy Engineering 2 credits

Elective Required
Professor Takatoshi Ito
Professor Hirokazu Moriya
Associate Professor Kiyotoshi Sakaguchi

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
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 Materials System 2 credits

Elective Required
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

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

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. Flow field at the cellular scale can be regarded as Stokes flow. We learn basic characteristics and mathematical descriptions of Stokes flow. Flow generated by flagella, swimming microorganisms, motions of vesicles and cells are discussed. Rheology of biofluids is explained by introducing various constitutive laws. Flow in a human body, flying birds, swimming fish and fluid mechanics in spots are lectured. We show fluid mechanics can be a strong tool to understand biological functions.

Special Lecture Series on Integrated Biomechanics I
2 credits

Elective Required
Professor Makoto Ohta
Associate Professor Kenji Kikuchi

The mechanical function and structure of living organisms will be described in detail from the standpoint of continuum mechanics. In particular, we will establish understanding for future research, such as fluid dynamics of blood flow and airflow, muscles, blood vessels, and cells as soft materials, and static and dynamics of skeletal systems as hard materials. Then, we will explain the measurement and visualization methods of the information from the living body and learn the principles of measurements for biological information and its application.
(Note) This course is offered in Japanese and English every other year and is offered in Japanese on 2021.

Intelligent Mechanosystem Analysis 2 credits

Elective Required
Associate Professor Kenichi Funamoto

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.

Nano-and Micro-Surface Metrology and Engineering
2 credits

Elective Required
Professor Wataru Yashiro

Measurement and control are the two wheels of manufacturing. The aim of this lecture is to learn the history of the development of conventional techniques for measurement and control methods covering a wide range of spatial scales from atomic to macroscopic scales of surfaces and interfaces that govern the function of materials. The ultimate goal of this lecture is to develop the ability to analyze for oneself what the limits of conventional measurement and control techniques are, and what problems have been essentially solved to open up new frontiers.

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 Administration 2 credits

Elective Required Various teachers

The Graduate School of Environmental Studies has had a cooperation agreement with Miyagi Prefecture and Sendai City, respectively.
In this lecture, students learn about current status and issues related to environmental policies of Miyagi Prefecture and Sendai City (about climate change such as global warming, promotion of waste reduction and recycling including plastic recycling, and environment-related laws) to achieve environmental conservation and sustainable society, and learn about environmental policies and environmental technologies.
In addition to lectures, this course can help students acquire practical knowledge and develop their ability to think about how to respond to environmental issues through exercise and facility tour.

Ethics of Engineering and Life 2 credits

Elective Required
Professor Tetsutaro Hattori

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 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.

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 1 or 2 credits

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 Finemechanics A 1 or 2 credits

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 Hitoshi Soyama
Professor Hideo Miura
Professor Hironori Tohmyoh
Professor Takeshi Yamaguchi
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 Wei Gao
Professor Taku Ohara
Professor Takashi Tokumasu
Professor Seiji Samukawa
Professor Wataru Yashiro
Associate Professor Hiraku Matsukuma
Associate Professor Shigeru Yonemura
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 Kenji 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 Intelligent Mechano-Systems 2 credits

Elective Required
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 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's Thesis Research in Finemechanics 8 credits

Required Various teachers

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.

開講授業科目表(MC)　Opening of a course class subject list

ロボティクス専攻
Department of Robotics

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門基盤科目 Major Basic Subjects	数値解析学	毎年 Every year	J		2		左記の専門基盤科目の内から4科目以上選択履修し，8単位以上修得すること. A student has to earn 8 or more credits from the Major basic subjects listed in the left column.
	Numerical Analysis	隔年 Every second year	E				
	確率モデル論 Probability Models	毎年 Every year	JE		2		
	基盤流体力学	毎年 Every year	J		2		
	Fluid Dynamics	毎年 Every year	E				
	固体力学	毎年 Every year	J		2		
	Solid Mechanics	毎年 Every year	E				
	熱科学・工学A	隔年 Every second year	J		2		
	Thermal Science and Engineering A	隔年 Every second year	E				
	熱科学・工学B	隔年 Every second year	J		2		
	Thermal Science and Engineering B	隔年 Every second year	E				
	システム制御工学Ⅰ System Control Engineering Ⅰ	毎年 Every year	E		2		
	システム制御工学Ⅱ System Control Engineering Ⅱ	毎年 Every year	E		2		
	材料化学 Materials Chemistry	毎年 Every year	E		2		
	計算機科学	隔年 Every second year	J		2		
	Computer Hardware Fundamentals	隔年 Every second year	E				
	固体物理学 Solid State Physics	毎年 Every year	E		2		
	塑性力学 Mechanics of Plasticity	毎年 Every year	E		2		
	生物の構造と機能	隔年 Every second year	J		2		
	Structure and Function of Living System	隔年 Every second year	E				
	ロボットビジョン	隔年 Every second year	J		2		
	Robot Vision	隔年 Every second year	E				
	ディジタル信号処理	隔年 Every second year	J		2		
	Digital Signal Processing	隔年 Every second year	E				
	力学と物理数学	隔年 Every second year	J		2		
	Introduction to Classical Mechanics and Physical Mathematics	隔年 Every second year	E				
	連続体力学	隔年 Every second year	J		2		
	Continuum Mechanics	隔年 Every second year	E				
	応用流体力学	隔年 Every second year	J		2		
	Applied Fluid Mechanics	隔年 Every second year	E				
	構造力学	隔年 Every second year	J		2		
	Structural Mechanics	隔年 Every second year	E				

開講授業科目表(MC)　Opening of a course class subject list

ロボティクス専攻
Department of Robotics

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				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	微小電気機械システム Micro Electro Mechanical Systems	毎年 Every year	E		2		左記の専門科目の内から少なくても1科目以上選択履修し2単位以上を修得するとともに，左記の科目，特別講義A，特別研修A，及び関連科目を選択履修し，全体で12単位以上を修得すること．ただし，特別講義A，特別研修Aで修得した単位は2単位まで本要件に含めることができる．なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる． A student has to earn 2 or more credits from the major general subjects listed in the left colum. In addition, 12 or more credits in total are required to earn from the Major general subjects, Advanced seminar A, Special lecture A, and related subjects offered by other departments. However, a total of 2 credits at most, obtained from advanced seminar A and Special lecture A, is included in this requirement. As an exception, a total of 8 credits obtained from Special lecture A is included in this requirement, when a student is enrolled in our double-dgree program or joint educationnal program.
	アドバンスドロボティクス Advanced Robotics	隔年 Every second year	E		2		
	バイオメカトロニクス Biomechatronics	隔年 Every second year	J		2		
	分子ロボティクス基礎	隔年 Every second year	J		2		
	Foundations of Molecular Robotics	隔年 Every second year	E				
	知的メカノシステム解析学 Intelligent Mechanosystem Analysis	隔年 Every second year	E		2		
	固体イオニクス論 Introduction to Solid State Ionics	隔年 Every second year	E		2		
	人間－ロボット情報学 Human-Robot Informatics	隔年 Every second year	E		2		
	流体設計情報学 Fluid Design Informatics	隔年 Every second year	E		2		
	ニューロロボティクス Neuro Robotics	隔年 Every second year	E		2		
	知能制御システム学 Intelligent Control Systems	隔年 Every second year	E		2		
	機能性流体工学 Functional Fluids Engineering	隔年 Every second year	E		2		
	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境行政論 Environmental Administration	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	毎年 Every year	JE		2		
	インターンシップ研修 Internship Training				1～2		
	国際学術インターンシップ研修 International Scientific Internship Training				1～2		
	ロボティクス特別講義A Special Lecture on Robotics A				1～2		
	ロボティクス特別研修A Advanced Seminar on Robotics A				1～2		
関連科目 Related Subjects of Other Majors	本研究科委員会において関連科目として認められたもの。 Those approved by the Educational Committee of the Graduate School of Engineering						
専門科目 Major General Subjects	ナノシステムセミナー Seminar on Nano-Systems	毎年 Every year	JE		2		左記のセミナーのいずれかを履修し，2単位を修得すること． A student has to earn 2 credits from one of the seminar listed in the left column.
	ロボットシステムセミナー Seminar on Robot-Systems	毎年 Every year	JE		2		
	ロボティクス修士研修 Master's Thesis Research in Robotics			8			

1．上記科目の単位数を合わせて30単位以上を修得すること。(Students must acquire 30 or more credits from the subjects above.)
2．『開講時期』については、現時点におけるものであり、変更になることもある。開講年度等は授業時間割等で確認すること。
"Class Schedule" is currently tentative and may be subject to change.
Make sure to check the fiscal years when each class is offered with the time schedule of the classes, program syllabus, etc.
3．『使用言語』欄のアルファベット記号について (Language key)
E：英語開講科目(Lectures given in English)
JE：準英語開講科目(Lectures given in Japanese, with English explanations)
J：日本語開講科目(Lectures given in Japanese)

Numerical Analysis 2 credits

Elective Required
Professor Naofumi Ohnishi

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.

Probability Models 2 credits

Elective Required
Associate Professor Reika Fukuizumi

Mathematical analysis is important for the understanding of random phenomenon appearing 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 Masaya Shigeta

Students acquire the intuition and knowledge of the nature of fluid motion by studying the fundamentals of Fluid Dynamics with not only theories but also visualized images, observation videos, and computer graphic animations. The goal is for students to be able to predict the fluid motion and to design the control methods in aerodynamic and material processing applications.
Keywords: Vortex, Convection, Stream/Path/Streak lines, Incompressibility/Compressibility, Conservation laws, Bernoulli's theorem, Viscosity and diffusivity, Boundary layer, Aerodynamic force, Laws of similarity, Reynolds number, Strouhal number and Kármán's vortex street, Analogy with heat and mass transfers, Navier-Stokes and wave equations.

Solid Mechanics 2 credits

Elective Required
Associate Professor Yoshiteru Aoyagi

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 A 2 credits

Elective Required
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Professor Takashi Tokumasu
Associate Professor Hisashi Nakamura

In this course, students will master the basic physics of reactive flows in thermal fluid science. In particular, the course is designed to cover flame behaviors and peculiar phenomena in laminar and turbulent combustion, the basic concept of chemical kinetics and the understanding of reaction phenomena of electrochemistry on the standpoint of thermal science.Through the class, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

Thermal Science and Engineering B 2 credits

Elective Required
Professor Taku Ohara
Professor Tetsushi Biwa
Professor Atsuki Komiya
Associate Professor Gota Kikugawa

The students will master the basic physics of thermal energy conversion and heat transfer in both micro and macroscopic scales, and learn to link this knowledge to engineering applications. More specifically, the series lectures: i) the Molecular Dynamics and molecular-scale analyses of thermo-fluid phenomena, ii) oscillating-flow based heat transfer and energy conversion, iii) visualization and control of multi-scale heat and mass transfer, and iv) statistical mechanics regarding interface phenomena will be done. Students are expected to further deepen their understanding of the essence of thermal phenomena.

System Control Engineering I 2 credits

Elective Required
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. This class includes some exercises using MATLAB.

System Control Engineering II 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Yusuke Tamura

This course gives an advanced lecture based on the contents of "System Control Engineering I." This lecture introduces the analysis and design methods of control systems used for designing motion control for increasingly advanced and complex mechanical systems. Students will learn fundamental concepts for state and output feedback in the state space, state observer and Kalman filter, and response analysis of control systems. This class includes some exercises using MATLAB.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
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 a lecture and practice 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
Professor Hiroyuki Takizawa

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 mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Professor Makoto Ohta
Professor Takuji Ishikawa

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.

Robot Vision 2 credits

Elective Required
Professor Takayuki Okatani

This course explains various problems and their solutions in computer vision. The problems are basically inverse-problems in which we wish to estimate some information about an object or a scene from their image(s), such as the three-dimensional shape of a scene or the categories of object. Students will first learn a series of fundamental concepts, and then study a number of approaches to the problems of computer vision, where the main focus is on the recently developed deep learning methods.

Digital Signal Processing 2 credits

Elective Required
Associate Professor Shingo Kagami
Associate Professor Toshinori Kuwahara

This lecture covers fundamentals of digital signal processing that provides a foundation for sensing, control, communication, voice processing, image processing, and so forth. Related subjects include discrete-time signals, discrete-time and discrete Fourier transformations, sampling, digital frequency analysis, discrete-time systems, z transformation, digital filtering, and some more advanced topics.

Introduction to Classical Mechanics and Physical Mathematics 2 credits

Elective Required
Professor Tomonaga Okabe

In the modeling of classical mechanics, we often meet the applied mathematics, such as differential geometry or manifolds theory. These have been developed from the viewpoint of mathematical universality and do not always provide new ideas directly. But, we often need such a background to make the theoretical models. Furthermore, symbols and calculations developed in these fields are not commonly used by general engineering students or graduate students of engineering, and this is considered to be an obstacle for learning them. In this lecture, I am going to introduce those mathematical expressions as simple as possible, so that the students can employ the advanced mathematics in the general mechanical engineering field. This course can also be considered as an introduction to the tools of physical mathematics.

Continuum Mechanics 2 credits

Elective Required
Professor Takuji Ishikawa

Materials may be regarded as continuum at the macroscopic scale. In this lecture, we aim to mathematically understand the motion and deformation of materials, such as solid and fluid, at the macroscopic scale. We first explain the concepts of continuum and stress as well as vector/tensor analysis. We then derive basic equations describing the motion and deformation of continuum, such as equilibrium equation, constitutive equation and boundary conditions. This lecture is the basis of solid and fluid mechanics, which is recommended to students who want to establish a whole picture of both subjects.

Applied Fluid Mechanics 2 credits

Elective Required
Professor Jun Ishimoto
Professor Yuka Iga

This lecture will be given on the fundamentals and applications of multiphase fluid dynamics and numerical analysis related to the fluid dynamic phenomena with heterogeneous interfaces, gas-liquid two-phase flow, phase change, cavitation, and the fundamentals of turbo-type fluid machinery such as pumps and turbines. The main topics to be understand are as follows. 1) Flow pattern and classification method of gas-liquid two-phase flow, 2) Fundamentals of two-fluid model, 3) Modeling of dispersed multi-phase flow and numerical analysis, 4) Modeling of liquid atomization 5) Classification and role of fluid machinery 6) Generation of cavitation in pumps.

Structural Mechanics 2 credits

Elective Required
Professor Kanjuro Makihara

This lecture gives a fundamental knowledge on the structural analysis and the structural design of mechanical structures. Main topics of this lecture are deformation and stress analyses of fuselage and wing structures subjected to bending, twisting and shear. (1) Fundamental of mechanical structure and material strength. (2) Vibration analysis for structures. (3) Applied load and stress analysis of mechanical structures. (4) Structural identification and structural health monitoring (5) Structural mechanics for aerospace engineering.

Micro Electro Mechanical Systems 2 credits

Elective Required
Professor Shuji Tanaka
Associate Professor Takashiro Tsukamoto

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.

Advanced Robotics 2 credits

Elective Required
Professor Yasuhisa Hirata
Associate Professor Yusuke Tamura

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

Molecular robotics is a technology for creating systems by combining logically designed molecules. The basis of molecular robotics are DNA nanotechnology and artificial cell engineering. DNA nanotechnology is used to create various nanostructures and molecular computers for molecular robot by designing the sequences of nucleic acid molecules such as DNA. Artificial cell engineering is a methodology to embed various functional molecules in vesicles called liposomes to create a cellular molecular robot. In addition, synthetic biology, which is a closely related subject to molecular robotics, will also be explained.

Intelligent Mechanosystem Analysis 2 credits

Elective Required
Associate Professor Kenichi Funamoto

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 Takashi Nakamura

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
Professor Kazunori Ohno
Associate Professor Masashi Konyo
Associate Professor Kenjiro Tadakuma

Fluid Design Informatics 2 credits

Elective Required
Professor Shigeru Obayashi
Associate Professor Koji Shimoyama

This lecture aims to construct the theories, learn the methodologies, and see the real-world examples of fluid engineering design, which is based on computational fluid dynamics (CFD) combined with information science. The lecture outline is organized as 1. design optimization, 2. gradient method, 3. evolutionary computation, 4. surrogate model, 5. physics-based optimization, and 6. data mining.

Neuro Robotics 2 credit

Elective Required
Professor Mitsuhiro Hayashibe
Associate Professor Dai Owaki

This course deals with key elements for Neuro-Robotics which is new scientific field to use robotics for neuroscience and use neuroscience for robotics. We learn robotics computation aspect and neuroscience knowledge to understand human functionality with the view of robotics, and robotics modeling and computation technology which is useful to understand human system of motor control and motor learning. It may include machine learning, neural network, Kalman filtering, control methods for computation aspect. The lecture is given in practical aspects as well as fundamental aspects for students who study neurorobotics and its related applications.

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.

Functional Fluids Engineering 2 credits

Elective Required
Professor Takehiko Sato
Professor Masaya Shigeta
Professor Hidemasa Takana

This course covers fluids that express functionality depending by external fields. We discuss fundamentals of fluids' structure, mechanism of exhibiting the functionalities, transport phenomena, governing equations, and diagnostic method for the functional fluids such as plasma fluid, magnetic fluid, MR or ER fluids, ionic liquid. Also, regarding advanced applications using functionalities of those fluids, we outline plasma medicine, environmental remediation, material processing, energy equipment and other topics.

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 Administration 2 credits

Elective Required Various teachers

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In addition to lectures, this course can help students acquire practical knowledge and develop their ability to think about how to respond to environmental issues through exercise and facility tour.

Ethics of Engineeing and Life 2 credits

Elective Required

Professor Tetsutaro Hattori

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 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.

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 Yoichi Haga Professor Yoshiaki Kanamori Associate Professor Shinichiro Nomura Associate Professor Takaki Tsukamoto 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 Mami Tanaka Professor Mitsuhiro Hayashibe Professor Yasuhisa Hirata Associate Professor Takeshi Okuyama Associate Professor Dai Owaki Associate Professor Yusuke Tamura 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's Thesis Research in Robotics** 8 credits Required Various teachers 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.

開講授業科目表(MC)　Opening of a course class subject list

航空宇宙工学専攻
Department of Aerospace Engineering

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門基盤科目 Major Basic Subjects	数値解析学	毎年 Every year	J		2		左記の専門基盤科目の内から4科目以上選択履修し，8単位以上修得すること. A student has to earn 8 or more credits from the Major basic subjects listed in the left column.
	Numerical Analysis	隔年 Every second year	E				
	確率モデル論 Probability Models	毎年 Every year	JE		2		
	基盤流体力学	毎年 Every year	J		2		
	Fluid Dynamics	毎年 Every year	E				
	固体力学	毎年 Every year	J		2		
	Solid Mechanics	毎年 Every year	E				
	熱科学・工学A	隔年 Every second year	J		2		
	Thermal Science and Engineering A	隔年 Every second year	E				
	熱科学・工学B	隔年 Every second year	J		2		
	Thermal Science and Engineering B	隔年 Every second year	E				
	システム制御工学 I System Control Engineering I	毎年 Every year	E		2		
	システム制御工学 II System Control Engineering II	毎年 Every year	E		2		
	材料化学 Materials Chemistry	毎年 Every year	E		2		
	計算機科学	隔年 Every second year	J		2		
	Computer Hardware Fundamentals	隔年 Every second year	E				
	固体物理学 Solid State Physics	毎年 Every year	E		2		
	塑性力学 Mechanics of Plasticity	毎年 Every year	E		2		
	生物の構造と機能	隔年 Every second year	J		2		
	Structure and Function Living System	隔年 Every second year	E				
	ロボットビジョン	隔年 Every second year	J		2		
	Robot Vision	隔年 Every second year	E				
	ディジタル信号処理	隔年 Every second year	J		2		
	Digital Signal Processing	隔年 Every second year	E				
	力学と物理数学	隔年 Every second year	J		2		
	Introduction to Classical Mechanics and Physical Mathematics	隔年 Every second year	E				
	連続体力学	隔年 Every second year	J		2		
	Continuum Mechanics	隔年 Every second year	E				
	応用流体力学	隔年 Every second year	J		2		
	Applied Fluid Mechanics	隔年 Every second year	E				
	構造力学	隔年 Every second year	J		2		
	Structural Mechanics	隔年 Every second year	E				

開講授業科目表(MC)　Opening of a course class subject list

航空宇宙工学専攻
Department of Aerospace Engineering

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	航空宇宙システム工学 Aerospace Systems	毎年 Every year	J		2		左記の専門科目の内から少なくても1科目以上選択履修し2単位以上を修得するとともに，左記の科目，特別講義A，特別研修A，及び関連科目を選択履修し，全体で12単位以上を修得すること．ただし，特別講義A，特別研修Aで修得した単位は2単位まで本要件に含めることができる．なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる． A student has to earn 2 or more credits from the major general subjects listed in the left colum. In addition, 12 or more credits in total are required to earn from the Major general subjects, Advanced seminar A, Special lecture A, and related subjects offered by other departments. However, a total of 2 credits at most, obtained from Advanced seminar A and Special lecture A, is included in this requirement. As an exception, a total of 8 credits obtained from Special lecture A is included in this requirement, when a student is enrolled in our double-dgree program or joint educationnal program.
	航空宇宙推進工学	隔年 Every second year	J		2		
	Aerospace Propulsion	隔年 Every second year	E				
	数値流体力学 Computational Fluid Dynamics	隔年 Every second year	E		2		
	航空宇宙流体力学 Aerospase Fluid Dynamics	隔年 Every second year	E		2		
	宇宙探査ロボティクス Robotics for Space Exploration	毎年 Every year	E		2		
	衛星工学 Spacecraft Engineering	毎年 Every year	E		2		
	計算数理科学 Mathematical Modeling and Computation	毎年 Every year	E		2		
	数理流体力学	隔年 Every second year	J		2		
	Applied Mathematical Fluid Dynamics	隔年 Every second year	E				
	高性能計算論 High Performance Computing	毎年 Every year	E		2		
	流体設計情報学 Fluid Design Informatics	隔年 Every second year	E		2		
	アーキテクチャ学 Computer Architecture	毎年 Every year	E		2		
	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境行政論 Environmental Administration	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	毎年 Every year	JE		2		
	JAXA連携特別講義 Special Lecture in Cooperation with JAXA	毎年 Every year	E		2		
	インターンシップ研修 Internship Training				1～2		
	国際学術インターンシップ研修 International Scientific Internship Training				1～2		
	航空宇宙工学特別講義A Special Lecture on Aerospace Engineering A				1～2		
	航空宇宙工学特別研修A Advanced Seminar on Aerospace Engineering A				1～2		
関連科目 Related Subjects of Other Majors	本研究科委員会において関連科目として認められたもの。 Those approved by the Educational Committee of the Graduate School of Engineering						
専門科目 Major General Subjects	航空システムセミナー Seminar on Aero Systems	毎年 Every year	JE		2		左記のセミナーのいずれかを履修し，2単位を修得すること． A student has to earn 2 credits from one of the seminar listed in the left column.
	宇宙システムセミナー Seminar on Space Systems	毎年 Every year	JE		2		
	航空宇宙工学修士研修 Master's Thesis Research in Aeronautics and Space Engineering			8			

1．上記科目の単位数を合わせて30単位以上を修得すること。(Students must acquire 30 or more credits from the subjects above.)
2．『開講時期』については、現時点におけるものであり、変更になることもある。開講年度等は授業時間割等で確認すること。
"Class Schedule" is currently tentative and may be subject to change.
Make sure to check the fiscal years when each class is offered with the time schedule of the classes, program syllabus, etc.
3．『使用言語』欄のアルファベット記号について (Language key)
E：英語開講科目(Lectures given in English)
JE：準英語開講科目(Lectures given in Japanese, with English explanations)
J：日本語開講科目(Lectures given in Japanese)

Numerical Analysis 2 credits

Elective Required
Professor Naofumi Ohnishi

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.

Probability Models 2 credits

Elective Required
Associate Professor Reika Fukuizumi

Mathematical analysis is important for the understanding of random phenomenon appearing 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 Masaya Shigeta

Students acquire the intuition and knowledge of the nature of fluid motion by studying the fundamentals of Fluid Dynamics with not only theories but also visualized images, observation videos, and computer graphic animations. The goal is for students to be able to predict the fluid motion and to design the control methods in aerodynamic and material processing applications.
Keywords: Vortex, Convection, Stream/Path/Streak lines, Incompressibility/Compressibility, Conservation laws, Bernoulli's theorem, Viscosity and diffusivity, Boundary layer, Aerodynamic force, Laws of similarity, Reynolds number, Strouhal number and Kármán's vortex street, Analogy with heat and mass transfers, Navier-Stokes and wave equations.

Solid Mechanics 2 credits

Elective Required
Associate Professor Yoshiteru Aoyagi

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 A 2 credits

Elective Required
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Professor Takashi Tokumasu
Associate Professor Hisashi Nakamura

In this course, students will master the basic physics of reactive flows in thermal fluid science. In particular, the course is designed to cover flame behaviors and peculiar phenomena in laminar and turbulent combustion, the basic concept of chemical kinetics and the understanding of reaction phenomena of electrochemistry on the standpoint of thermal science.Through the class, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

Thermal Science and Engineering B 2 credits

Elective Required
Professor Taku Ohara
Professor Tetsushi Biwa
Professor Atsuki Komiya
Associate Professor Gota Kikugawa

The students will master the basic physics of thermal energy conversion and heat transfer in both micro and macroscopic scales, and learn to link this knowledge to engineering applications. More specifically, the series lectures: i) the Molecular Dynamics and molecular-scale analyses of thermo-fluid phenomena, ii) oscillating-flow based heat transfer and energy conversion, iii) visualization and control of multi-scale heat and mass transfer, and iv) statistical mechanics regarding interface phenomena will be done. Students are expected to further deepen their understanding of the essence of thermal phenomena.

System Control Engineering I 2 credits

Elective Required
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. This class includes some exercises using MATLAB.

System Control Engineering II 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Yusuke Tamura

This course gives an advanced lecture based on the contents of "System Control Engineering I." This lecture introduces the analysis and design methods of control systems used for designing motion control for increasingly advanced and complex mechanical systems. Students will learn fundamental concepts for state and output feedback in the state space, state observer and Kalman filter, and response analysis of control systems. This class includes some exercises using MATLAB.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
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 a lecture and practice 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
Professor Hiroyuki Takizawa

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 mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Professor Makoto Ohta
Professor Takuji Ishikawa

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.

Robot Vision 2 credits

Elective Required
Professor Takayuki Okatani

This course explains various problems and their solutions in computer vision. The problems are basically inverse-problems in which we wish to estimate some information about an object or a scene from their image(s), such as the three-dimensional shape of a scene or the categories of object. Students will first learn a series of fundamental concepts, and then study a number of approaches to the problems of computer vision, where the main focus is on the recently developed deep learning methods.

Digital Signal Processing 2 credits

Elective Required
Associate Professor Shingo Kagami
Associate Professor Toshinori Kuwahara

This lecture covers fundamentals of digital signal processing that provides a foundation for sensing, control, communication, voice processing, image processing, and so forth. Related subjects include discrete-time signals, discrete-time and discrete Fourier transformations, sampling, digital frequency analysis, discrete-time systems, z transformation, digital filtering, and some more advanced topics.

Introduction to Classical Mechanics and Physical Mathematics 2 credits

Elective Required
Professor Tomonaga Okabe

In the modeling of classical mechanics, we often meet the applied mathematics, such as differential geometry or manifolds theory. These have been developed from the viewpoint of mathematical universality and do not always provide new ideas directly. But, we often need such a background to make the theoretical models. Furthermore, symbols and calculations developed in these fields are not commonly used by general engineering students or graduate students of engineering, and this is considered to be an obstacle for learning them. In this lecture, I am going to introduce those mathematical expressions as simple as possible, so that the students can employ the advanced mathematics in the general mechanical engineering field. This course can also be considered as an introduction to the tools of physical mathematics.

Continuum Mechanics 2 credits

Elective Required
Professor Takuji Ishikawa

Materials may be regarded as continuum at the macroscopic scale. In this lecture, we aim to mathematically understand the motion and deformation of materials, such as solid and fluid, at the macroscopic scale. We first explain the concepts of continuum and stress as well as vector/tensor analysis. We then derive basic equations describing the motion and deformation of continuum, such as equilibrium equation, constitutive equation and boundary conditions. This lecture is the basis of solid and fluid mechanics, which is recommended to students who want to establish a whole picture of both subjects.

Applied Fluid Mechanics 2 credits

Elective Required
Professor Jun Ishimoto
Professor Yuka Iga

This lecture will be given on the fundamentals and applications of multiphase fluid dynamics and numerical analysis related to the fluid dynamic phenomena with heterogeneous interfaces, gas-liquid two-phase flow, phase change, cavitation, and the fundamentals of turbo-type fluid machinery such as pumps and turbines. The main topics to be understand are as follows. 1) Flow pattern and classification method of gas-liquid two-phase flow, 2) Fundamentals of two-fluid model, 3) Modeling of dispersed multi-phase flow and numerical analysis, 4) Modeling of liquid atomization 5) Classification and role of fluid machinery 6) Generation of cavitation in pumps.

Structural Mechanics 2 credits

Elective Required
Professor Kanjuro Makihara

This lecture gives a fundamental knowledge on the structural analysis and the structural design of mechanical structures. Main topics of this lecture are deformation and stress analyses of fuselage and wing structures subjected to bending, twisting and shear. (1) Fundamental of mechanical structure and material strength. (2) Vibration analysis for structures. (3) Applied load and stress analysis of mechanical structures. (4) Structural identification and structural health monitoring (5) Structural mechanics for aerospace engineering.

Aerospace Systems 2 credits

Elective Required
Professor Naofumi Ohnishi
Adjunct Instructor Koichi Yonemoto
Adjunct Instructor Toshihiko Nakagawa
Adjunct Instructor Soichiro Yada

Lectures give the system concept of aircraft and rocket, and discuss the basic design planning and the performance of these flight vhicles.

Aerospace Propulsion 2 credits

Elective Required
Professor Naofumi Ohnishi
Associate Professor Masayuki Takahashi

Lectures on principles of thrust generation of jet engine and rocket engine which propel vehicles in air and space are given, including structure of the engines and methods for improving their performance. Non-chemical propropulsion schemes are also introduced, including physics of plasma.

Computational Fluid Dynamics 2 credits

Elective Required
Professor Soshi Kawai

In this course, the basics of modern computational fluid dynamics (CFD) methods for compressible flow simulations and programming of numerical methods are given. Accuracy and errors of finite difference methods, the meaning of central and upwind schemes, finite volume methods (conservation law and numerical flux), and recent high-order accurate numerical methods are given. Also, we will provide lectures on the programming of numerical methods discussed in this course.

Aerospace Fluid Dynamics 2 credits

Elective Required
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.

Robotics for Space Exploration 2 credits

Elective Required
Professor Kazuya Yoshida

Robotics technology is useful for space development and exploration activities. In this course, the subject of Space Robotics is elaborated on the application to orbital servicing missions and lunar/planetary exploration.
As for the "orbital robotics," the following topics are lectured:
- Angular motion kinematics and attitude dynamics of a spacecraft,
- Multi-body dynamics and control of a free-flying space robot,
- Impact dynamics and post-impact control when a space robot captures a floating target.

As for the "lunar/planetary robotics," the following topics are lectured:
- Mission and system design for Lunar and asteroid exploration,
- Mobility system design and analysis for locomotion on the lunar/planetary surface,
- Sensing, planning, and navigation of a mobile robot.

All lectures are given in English.

Spacecraft Engineering 2 credits

Elective Required
Professor Kazuya Yoshida
Professor Kanjuro Makihara
Professor Hiroki Nagai
Associate Professor Toshinori Kuwahara

In this course, the fundamental engineering issues are lectured in the following four parts for the design and development of spacecraft and space flight systems.
(1) Orbital mechanics for various space missions
(2) Attitude dynamics and control of spacecraft
(3) Design of space structures, vibration analysis and control
(4) Thermodynamics and thermal control of space systems
All lectures are given in English.

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 Hattori
Associate Professor Makoto Hirota

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.

High Performance Computing 2 credits

Elective Required
Professor Hiroyuki Takizawa

This course reviews high-performance computing 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 high-performance computing.

Fluid Design Informatics 2 credits

Elective Required
Professor Shigeru Obayashi
Associate Professor Koji Shimoyama

This lecture aims to construct the theories, learn the methodologies, and see the real-world examples of fluid engineering design, which is based on computational fluid dynamics (CFD) combined with information science. The outline of this lecture is organized as 1. design optimization, 2. gradient method, 3. evolutionary computation, 4. surrogate model, 5. physics-based optimization, 6. data mining, and 7. real-world applicaitons.

Computer Architecture 2 credits

Elective Required
Professor Hiroaki Kobayashi
Assosiate Professor Masayuki Sato

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 for more details.
http://www.sc.isc.tohoku.ac.jp/class/architecture/
(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.

Environmental Administration 2 credits

Elective Required Various teachers

The Graduate School of Environmental Studies has had a cooperation agreement with Miyagi Prefecture and Sendai City, respectively.
In this lecture, students learn about current status and issues related to environmental policies of Miyagi Prefecture and Sendai City (about climate change such as global warming, promotion of waste reduction and recycling including plastic recycling, and environment-related laws) to achieve environmental conservation and sustainable society, and learn about environmental policies and environmental technologies. In addition to lectures, this course can help students acquire practical knowledge and develop their ability to think about how to respond to environmental issues through exercise and facility tour.

Ethics of Engineering and Life 2 credits

Elective Required
Professor Tetsutaro Hattori

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 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.

Special Lecture in Cooperation with JAXA 2 credits

Elective Required
Visiting Professor Sadatake Tomioka
Visiting Professor Hideyuki Tanno

Visiting teachers from JAXA (Japan Aerospace Exploration Agency) make special lecture on future space transportation system. Major topics are system and components of liquid rocket engines, hypersonic air-breathing engines including combined cycle engine, as well as hypersonic aerodynamics for both hypersonic flight and re-entry.

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 1 or 2 credits

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 1 or 2 credits

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 Tomonaga Okabe
Professor Shigeru Obyashi
Professor Hiroki Nagai
Professor Soshi Kawai
Associate Professor Taku Nonomura
Associate Professor Koji Shimoyama
Associate Professor Go Yamamoto
Associate Professor Keiichi Shirasu
Associate Professor Yuichi Kuya

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 Naofumi Ohnishi
Professor Kazuya Yoshida
Professor Hideaki Kobayashi
Professor Kanjuro Makihara
Visiting Professor Sadatake Tomioka
Visiting Professor Hideyuki Tanno
Associate Professor Toshinori Kuwahara
Associate Professor Masayuki Takahashi

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's Thesis Research in Aeronautics and Space Engineering 8 credits

Required Various teachers

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.

開講授業科目表(MC)　Opening of a course class subject list

量子エネルギー工学専攻
Department of Quantum Science and Energy Engineering

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門基盤科目 Major Basic Subjects	原子炉工学 Nuclear Reactor Engineering	隔年 Every second year	J		2		左記の専門基盤科目の内から4科目以上選択履修し，8単位以上修得すること. なお、2科目(4単位)まで、「応用科学専攻」「化学工学専攻」「バイオ工学専攻」の専門基盤科目の選択履修を認める場合があるので、希望者は予め専攻長または大学院教務委員に届け出ること。 A student has to earn 8 or more credits from the Major basic subjects listed in the left column. In addition, the applicant report it to the Department Chair or the Graduate School of Engineering Educational Affairs Committee beforehand because I may accept the choice study of the Major Basic Subjects of the ″Department of Applied Chemistry″ ″Department of Chemical Engineering″ ″Department of Biomolecular Engineering″ to 2 subjects (4 credits).
	核エネルギーシステム安全工学 Safety Engineering of Nuclear Energy Systems	隔年 Every second year	J		2		
	粒子ビーム科学 Science and Engineering of Particle Beam	隔年 Every second year	J		2		
	プラズマ物理･核融合学 Plasma Physics and Fusion Energy	隔年 Every second year	J		2		
	固体物理 Solid State Physics	隔年 Every second year	J		2		
	材料化学 Materials Chemistry	毎年 Every year	E		2		
専門科目 Major General Subjects	量子･統計力学 Quantum and Statistical Mechanics	隔年 Every second year	J		2		左記の専門科目の内から少なくとも2科目以上選択履修し4単位以上を修得すること. なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる. A student has to earn 4or more credits from the major general subjects listed in the left colum.
	量子ビームシステム工学 System Engineering of Particle and Photon Beams	*1			2		
	エネルギーフロー環境工学 Environmental Perspective on the Energy Flow	隔年 Every second year	J		2		
	中性子デバイス工学 Engineering for Neutron Devices and Reactors	隔年 Every second year	J		2		
	保全工学 Basics for Plant Life Management	隔年 Every second year	J		2		
	核エネルギーシステム材料学 Materials for Nuclear Energy Systems	隔年 Every second year	J		2		
	実験原子力システム工学 Experimentals for Auantum Science and Nuclear Engnieering	毎年 Every year	J		2		
	先進原子力総合実習 Advanced Practical Nuclear Engineering	毎年 Every year	J		1		
	原子力基盤コンクリート工学 Concrete for Nuclear Power Plants	毎年 Every year	J		2		
	総合耐震工学 General Earthquake Engineering	毎年 Every year	J		2		
	原子力安全の論理と規制 Nuclear Safety Theory and Regulation	毎年 Every year	J		2		
	原子炉廃止措置工学 Engineering for Nuclear Reactor Decommissioning	毎年 Every year	J		2		
	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境行政論 Environmental Administration	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	毎年 Every year	JE		2		

開講授業科目表(MC)　Opening of a course class subject list

量子エネルギー工学専攻
Department of Quantum Science and Energy Engineering

区分 Category	授業科目　Subject	開講時期 Schedule	使用言語 Language	単位　Credit			備考　Remarks
				必修 Required	選択必修 Elective Required	選択 Elective	
専門科目 Major General Subjects	インターンシップ研修 Internship Training				1～2		特別講義A，特別研修Aで修得した単位は2単位まで修了要件に含めることができる．なお，共同教育プログラムの学生に限り，特別講義Aの単位を8単位まで本要件に含めることができる． A total of 2 credits at most, obtained from Advanced seminar A and Special lecture A, is included in the MC completion requirement. As an exception, a total of 8 credits obtained from Special lecture A is included in the requirement, when a student is enrolled in our double-dgree program or joint educationnal program.
	国際学術インターンシップ研修 International Scientific Internship Training				1～2		
	量子エネルギー工学特別講義A Special Lecture on Quantum Energy Engineering A				1～2		
	量子エネルギー工学特別研修A Advanced Seminar on Quantum Energy Engineering A				1～2		
関連科目 Related Subjects of Other Majors	本研究科委員会において関連科目として認められたもの。 Those approved by the Educational Committee of the Graduate School of Engineering						
専門科目 Major General Subjects	先進原子核工学セミナー Seminar on Advanced Nuclear Energy Engineering	毎年 Every year	JE		2		左記のセミナーのいずれかを履修し，2単位を修得すること． A student has to earn 2 credits from one of the seminar listed in the left column
	原子核システム安全工学セミナー Seminar on Safety Engineering of Nuclear Energy Systems	毎年 Every year	JE		2		
	エネルギー物理工学セミナー Seminar on Energy Physics Engineering	毎年 Every year	JE		2		
	粒子ビーム工学セミナー Seminar on Particle-Beam Engineering	毎年 Every year	JE		2		
	エネルギー材料工学セミナー Seminar on Energy Materials	毎年 Every year	JE		2		
	エネルギー化学工学セミナー Seminar on Energy Chemical Engineering	毎年 Every year	JE		2		
	量子物性工学セミナー Seminar on Quantum Theoretic Materials Engineering	毎年 Every year	JE		2		
	加速器放射線工学セミナー Seminar on Accelerator Radiation Science and Engineering	毎年 Every year	JE		2		
	量子エネルギー工学修士研修 Master's Thesis Research in Quantum Science and Energy Engineering			8			

1．上記科目の単位数を合わせて30単位以上を修得すること。(Students must acquire 30 or more credits from the subjects above.)
2．『開講時期』については、現時点におけるものであり、変更になることもある。開講年度等は授業時間割等で確認すること。
"Class Schedule" is currently tentative and may be subject to change.
Make sure to check the fiscal years when each class is offered with the time schedule of the classes, program syllabus, etc.
3．『使用言語』欄のアルファベット記号について (Language key)
E：英語開講科目(Lectures given in English)
JE：準英語開講科目(Lectures given in Japanese, with English explanations)
J：日本語開講科目(Lectures given in Japanese)
＊1：この授業の受講については、教務委員に問い合わせること。(Contact the Academic Affairs Committee for more information about taking this class.)

修了要件単位数
Credits requirement for MC completion

専門基盤科目　Major Basic Subjects	8 credits or more
専門科目　Major General Subjects (excluding the subjects below)	4 credits or more
専門科目　Major General Subjects ・Internship Training ・International Scientific Internship Training ・Special Lecture　A ・Advanced Seminar A	
関連科目 Related Subjects of Other Majors	
セミナー　Seminar	2 credits
修士研修　Master Course Seminar	8 credits
合計 Total	30 credits or more

Nuclear Reactor Engineering 2 credits

Elective Required
Professor Hidetoshi Hashizume
Associate Professor Shinji Ebara

The objective of this class is to understand the basics and applications of thermal fluids and electromagnetic phenomena in nuclear reactors and to respond to national examination together with system modeling capability from the viewpoint of integrated engineering. The main contents are;
1. Heat transfer related to fuel rods
2. Basic matter about boiling and application
3. Pipe flow and natural convection
4. Structural analysis
5. Thermal-hydraulics in a nuclear reactor plant
6. Modeling of turbulence flow

Safety Engineering of Nuclear Energy Systems
2 credits

Elective Required
Professor Makoto Takahashi
Associate Professor Daisuke Karikawa

The design of huge complex system such as nuclear power plant is presented in this lecture with the emphasis on the design for safety,redundant system, defense on depth. The basics of relibility engineering, probabilistic safety accessment and human reliability analysis are also lectured.
In the latter half of the lecure, students perform simulation based practical training using PC-based nuclear power plant simulator in order to understand the basic plant behavior and the possible scenarios of severe accidents simulating what happened in the Fukushima Daiichi nuclear power plant accident.

Science and Engineering of Particle Beam 2 credits

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

Plasma Physics and Fusion Energy 2 credits

Elective Required
Professor Kenji Tobita
Visiting Associate Professor Akinobu Matsuyama

The objective of this class is to build an overall understanding of fusion energy. The course will cover plasma physics, fusion engineering, fusion power system and its characteristics. Plasma physics will focus on fundamental understanding on how plasma behaves, how to confine high temperature plasma with magnetic fields, and how to heat the plasma up to 100 million ºC for fusion power production. Based on the fundamental physics, the course will address the concept of the fusion power system and fusion-relevant technologies to realize fusion energy, covering superconducting magnet, divertor, plasma heating systems. In the last part of the course, safety, environmental and socioeconomic aspects of fusion power will be presented.

Solid State Physics 2 credits

Elective Required
Professor Dai Aoki
Associate Professor Keitaro Hitomi

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.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
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 a lecture and practice style, using English-language materials. A detailed outline of the course will be presented during the first class.

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

Environmental Perspective on the Energy Flow
2 credits

Elective Required
Professor Yuichi Niibori
Associate Professor Seong-Yun Kim
Associate Professor Taiji Chida
Visiting Professor Masayuki Watanabe

The purpose of this class is to understand quantitatively the relations of primary energies and global environment based on "Energy Flow", which is an national energy balance. Besides, the utility of mass or heat balance is learned in order to find out what the esseintial issue is through some topics including fossil fuel, global warming, acid rain and radioactive wastes of nuclear energy. Furthermore, the advanced analytical chemistry regarding natural enviroment and nuclear energy, the reprocessing of spent fuel, the safety assessment of geological disposal system regarding radioactive wastes, and so on are discussed.

Neutron Devices Engineering 2 credits

Elective Required
Professor Shigeo Matsuyama
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.

Basics for Plant Life Management 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Tetsuya Uchimoto
Professor Noritaka Yusa
Associate Professor Hiroshi Abe

This course covers the fundamentals and theories of maintenance of plant equipment, mainly nuclear power plants. It includes the basic concept of maintenance, aging phenomena of structural materials, inspection techniques, integrity evaluation, and deterioration countermeasure techniques. The main aging phenomena are pipe thinning, stress corrosion cracking, embrittlement, fatigue, etc. Phenomenology, examples, mechanisms and control techniques are lectured for each deterioration mode. Special lectures and discussions by experts from industry and government will be provided as necessary.

Materials for Nuclear Energy Systems 2 credits

Elective Required
Professor Ryuta Kasada
Associate Professor Shuhei Nogami
Associate Professor Sosuke Kondo

The purpose of this lecture is to learn the relationship between nuclear energy systems, such as fission reactors and fusion reactors, and the various materials used in the nuclear energy systems.
In order to understand the role of materials in the nuclear energy systems, students learn the concept of stability of energy systems in a broad views. Students will participate in workshop-style group exercises to recognize and explain the stability of energy systems and learn system dynamics methods that can be applied to the investigation and analysis of energy system stability.
Irradiation damage, which is a phenomenon unique to materials used in nuclear energy systems, and the resulting irradiation effects will be introduced. The overall concept of structural integrity of nuclear energy systems that use materials with irradiation effects will be shown with focusing on specific examples in reactor pressure vessel steels. Students will learn the basics of environmental resistance and accident behavior of materials used in nuclear energy systems, as well as the status of accident-resistant fuels that have been developed in recent years.
Based on the previous engineering knowledge, students are expected to learn about the concept of the lifetime of nuclear energy systems from not only an engineering perspective but also a social perspective. In addition, students will be able to recognize their own viewpoints on the relationship between nuclear energy systems and society, and discuss them with others through exercises.

Experimental Nuclear System Engineering
2 credits

Elective Required
Professor Shigeo Matsuyama

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 credit

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

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.

Nuclear Safety Theory and Regulation 2 credits

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

Engineering for Nuclear Decommissioning 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Yuichi Niibori
Professor Makoto Takahashi
Specially Appointed Professor Koji Dozaki
Visiting Professor Masahiro Yamamoto

This lecture mainly focuses on the Fukushima Dai-ichi Nuclear Power Station, and provides the necessary theories for the safe decommissioning of nuclear reactors after a severe accident. This lecture focuses on the current status of Fukushima Daiichi NPS, lessons learned from past core disruptive accidents, current status and issues of decommissioning research, various efforts for technological development issues, as well as the current status of academic infrastructure such as the concept of ensuring long-term integrity of steel and RC structures during decommissioning, basics of fuel debris, treatment and disposal, and risk communication.

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 Adminisitration 2 credits Elective Required Various teachers	**Ethics of Engineering and Life** 2 credits Elective Required Professor Tetsutaro Hattori 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 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.
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 Quantum Energy Engineering A 1 or 2 credits 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** 1 or 2 credits 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 2 credits Elective Required Various teacher 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 credits Elective Required Professor Yutaka Watanabe Professor Yuichi Niibori Professor Makoto Takahashi Professor Noritaka Yusa Associate Professor Daisuke Karikawa Associate Professor Hiroshi Abe Associate Professor Taiji 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 Kenji Tobita
Associate Professor Satoru Ito
Associate Professor Shinji Ehara

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 Shigeo Matsuyama
Associate Professor Youhei Kikuchi
Associate Professor Shuhei Nogami
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.

Seminar on Energy Materials 2 credits

Elective Required
Professor Yasuyoshi Nagai
Professor Ryuta Kasada
Associate Professor Koji Inoue
Associate Professor Takeshi Toyama
Associate Professor Kenta Yoshida
Associate Professor Sosuke Kondo

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 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 Eiji Akiyama
Professor Dai Aoki
Associate Professor Motomichi Koyama

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
Professor Hiroshi Watabe
Professor Atsuki Terakawa

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's Thesis Research in Quantum Science and Energy Engineering 8 credits

Required Various teachers

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.

Curriculum Map

A curriculum map is a diagram that systematically summarizes the courses offered by the undergraduate school to the courses offered by the Graduate School of Engineering. Please refer to it when selecting classes.

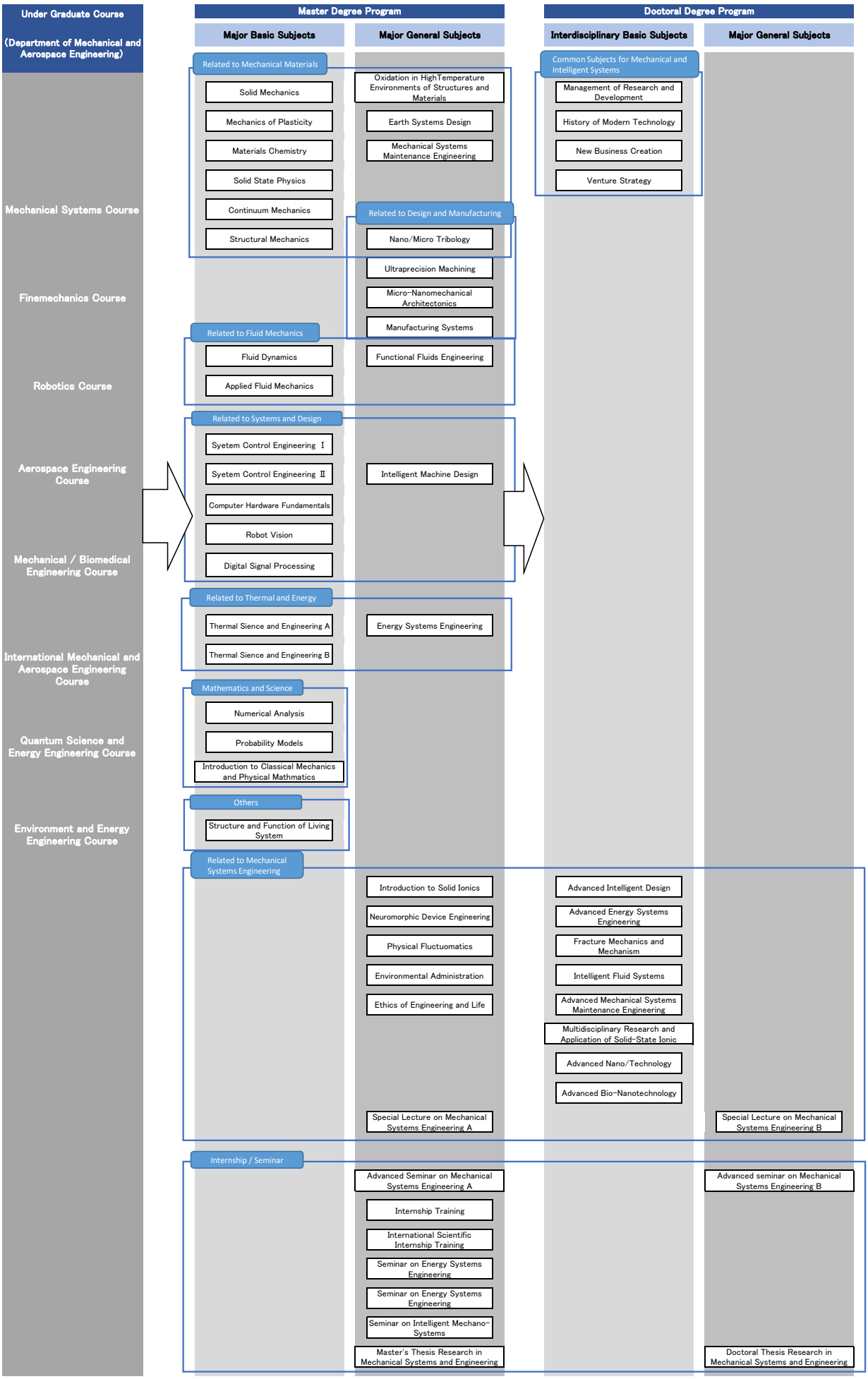
Classes are related each other, and unless you study them systematically from the basics to the advanced, you will not be able to truly understand and research the field. Please be aware of the connections and linkages between courses, and make a systematic course plan for the field of study you wish to pursue.

Grades may be written as follows;

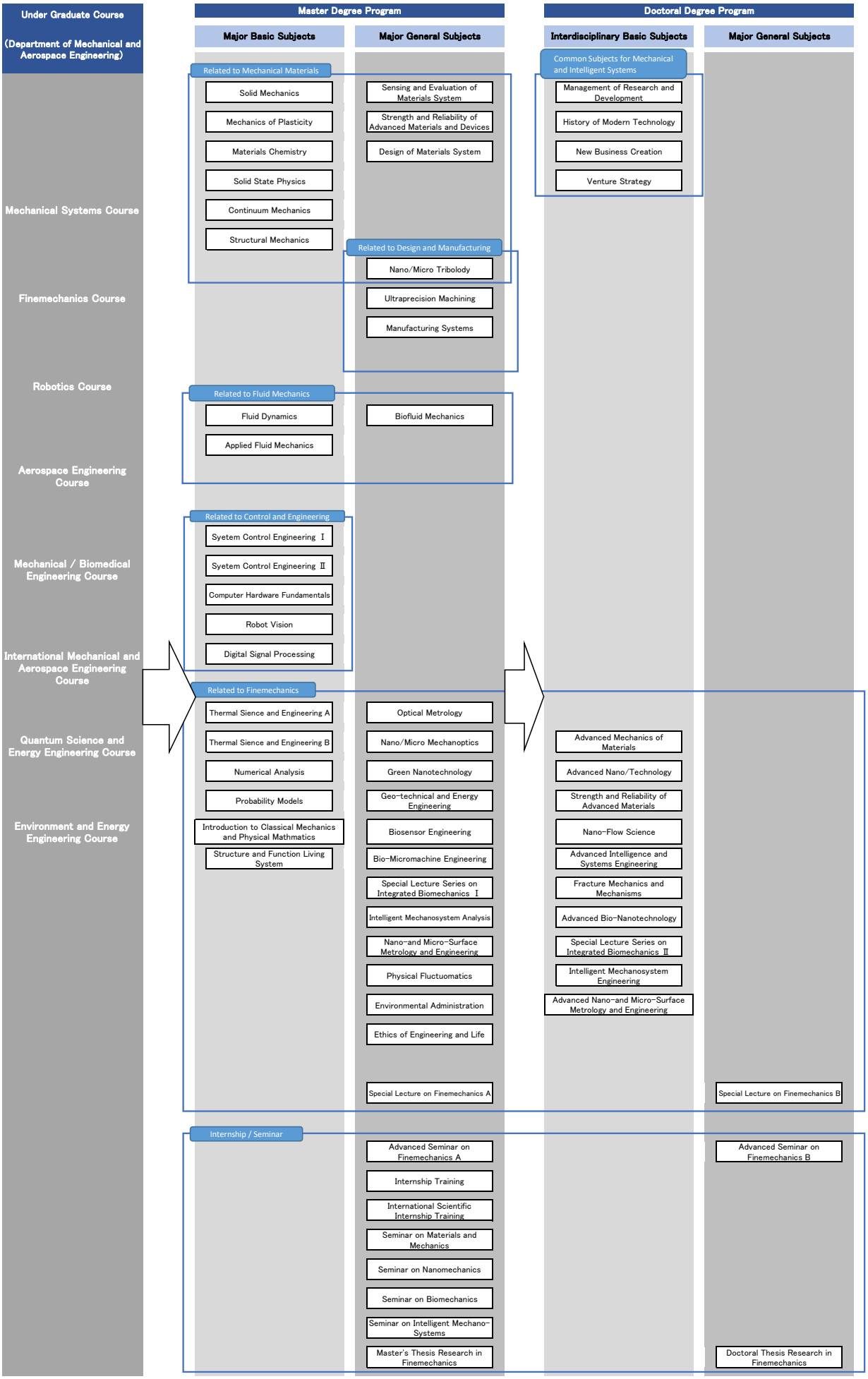
B1 First year Undergraduate student
B2 Second year Undergraduate student
B3 Third year Undergraduate student
B4 Forth year Undergraduate student

M1 Master Course first year student
M2 Master Course second year student
D1 Doctoral Course first year student
D2 Doctoral Course second year student
D3 Doctoral Course third year student

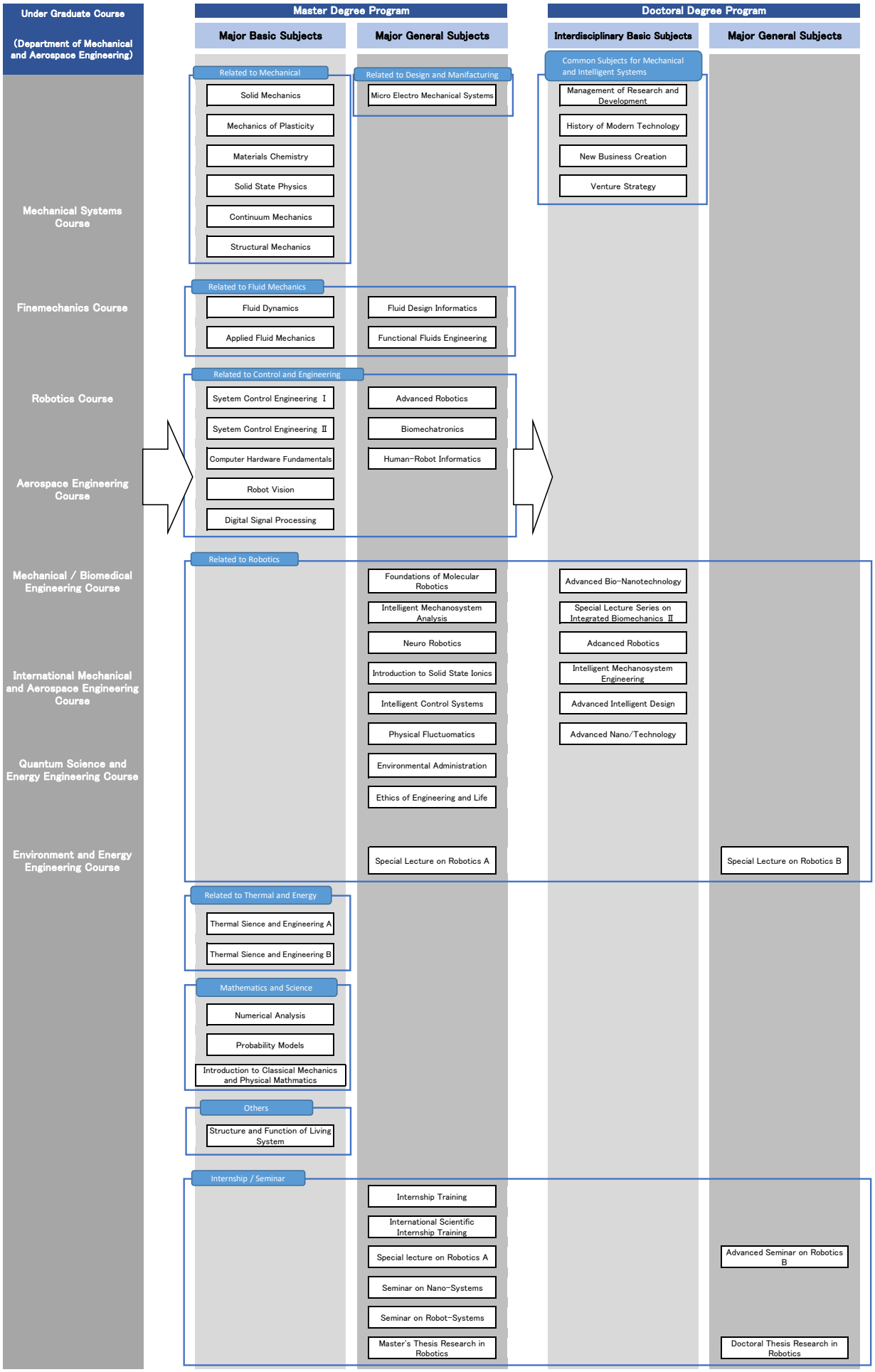
Department of Mechanical Systems Engineering



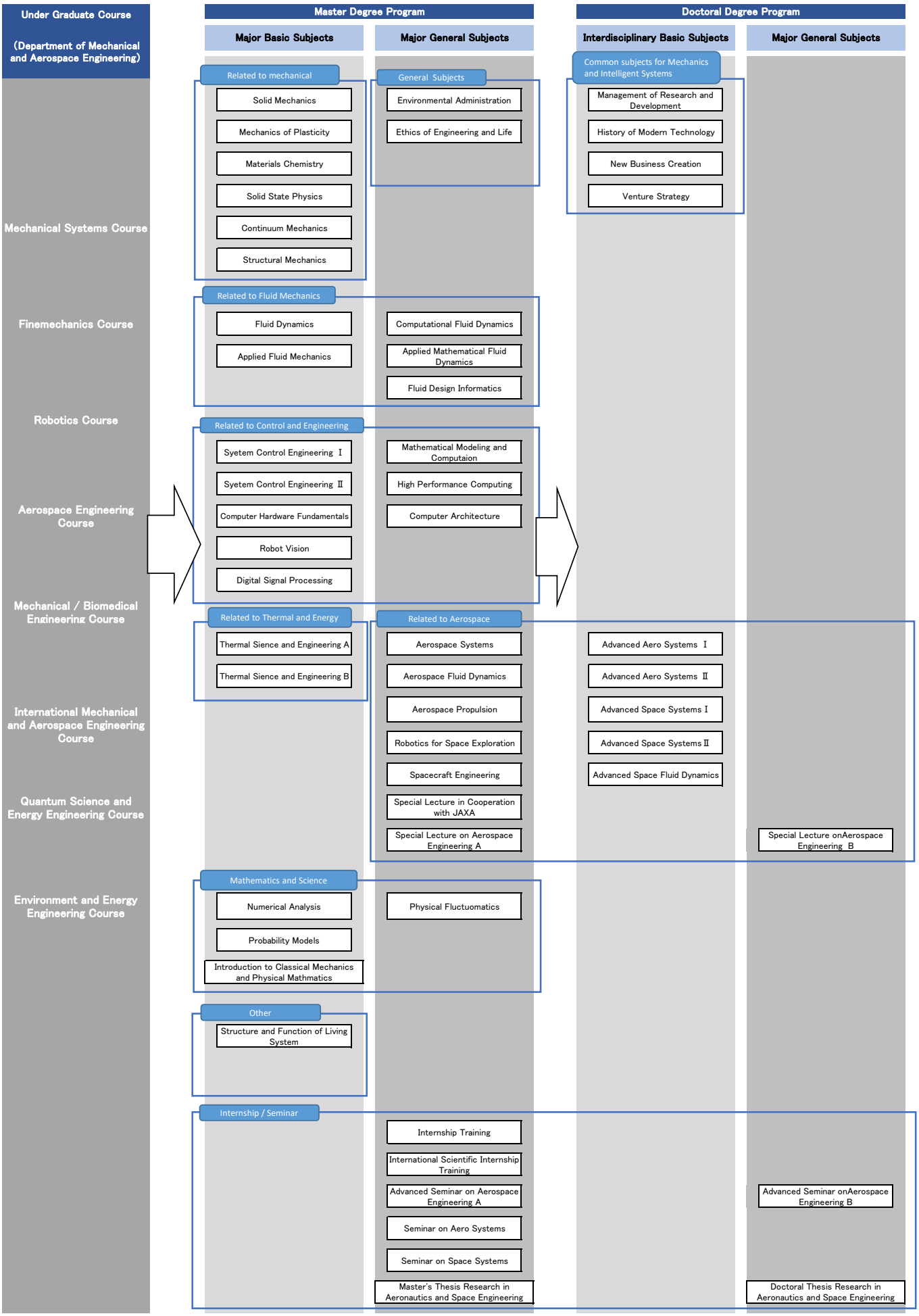
Department of Finemechanics



Department of Robotics



Department of Aerospace Engineering



Department of Quantum Science and Energy Engineering