2020 Enrollment

Course List and Summary

Master's Degree Program

授業科目表(MC)　List of Courses

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 Robot Vision	毎年 Every year	E		2		
	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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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 Nano/Micro Tribology	隔年 Every second year	J E		2		
	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 Oxidation in High Temperature Environments of Structures and Materials	隔年 Every second year	J E		2		
	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 Ultraprecision Machining	隔年 Every second year	J E		2		
	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 Earth Systems Design	隔年 Every second year	J E		2		
	ニューロモルフィックデバイス工学 Neuromorphic Device Engineering	隔年 Every second year	J E		2		
専門科目 Major General Subjects	物理フラクチュオマティクス論 Physical Fluctuomatics	毎年 Every year	J		2		
	環境技術政策論 Discussion on Environmental and Industrial Policy	毎年 Every year	J		2		
	工学と生命の倫理 Ethics of Engineering and Life	隔年 Every year	JE		2		
	融合領域研究合同講義 Interdisciplinary Research	毎年 Every year	J		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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専門科目 Major General Subjects	機械機能創成修士研修 Master Course Seminar on Mechanical Systems 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 Keisuke Sawada
Professor Soshi Kawai

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

Solid Mechanics 2 credits

Elective Required
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 singular 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 further deepen their understanding of the essence of thermal phenomena.

System Control Engineering I 2 credits

Elective Required
Professor Kazuya Yoshida
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 Kazuhiro Kosuge
Professor Koichi Hashimoto
Associate Professor Shogo Arai

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 and 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.

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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

Aerospace Propulsion 2 credits

Elective Required
Professor Naofumi Ohnishi

Computational Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada
Professr Soshi Kawai

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

Aerospace Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Asai
Associate Professor Taku Nonomura

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

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 applications.

Computer Architecture 2 credits

Elective Required
Professor Hiroaki Kobayashi
Associate 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
http://www.sc.isc.tohoku.ac.jp/class/architecture/ for more details.
(Contact instructors to have an access ID).

Physical Fluctuomatics 2 credits

Elective Required

Professor Kazuyuki Tanaka

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

Environmental and Technology Policy 2 credits

Elective Required Various teachers

Ethics of Engineering and Life 2 credits

Elective Required

Professor Tatsuo Yoshinobu

Adjunct Instructor Seishi Kudo

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

Interdisciplinary Research 2 credits

Elective Required Various teachers

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.