2021 Enrollment

Course List and Summary

Doctoral Degree Program

授業科目表(DC) 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	
学際基盤科目 Interdisciplinary Basic Subjects	研究開発マネージメント論 Managegement of Research and Development	毎年 Every year	JE		2		左記の学際基盤科目，特別講義B，特別研修B，及び関連科目の内から4科目以上を選択履修し，8単位以上を修得すること．なお，特別講義Bと特別研修B及び関連科目で修得した単位は4単位まで本要件に含めることができる． A student has to earn 8 or more credits from the left column. However, a total of 4 credits at most, obtained from Advanced seminar B, Special lecture B,and Related subjects are included in this requirement.
	近代技術史学 History of Modern Technology	毎年 Every year	J		2		
	ベンチャー・ビジネス論 Venture Management	毎年 Every year	J		2		
	ベンチャー企業戦略 Venture Strategy		J		2		
	知的デザイン学特論 Advanced Intelligent Design		E		2		
	エネルギーシステム工学特論 Advanced Energy Systems Engineering		E		2		
	破壊機構学特論 Fracture Mechanics and Mechanisms	毎年 Every year	E		2		
	知能流体システム学特論 Intelligent Fluid Systems		E		2		
	機械システム保全学特論 Advanced Mechanical Systems Maintenance Engineering		E		2		
	多元物質応用システム工学特論 Multidisciplinary Research and Application of Solid-State Ionic Devices	隔年 Every second year	E		2		
	ナノテクノロジー特論 Advanced Nano/Technology		E		2		
	バイオナノテクノロジー特論 Advanced Bio-Nanotechnology	隔年 Every second year	E		2		
	Advanced Mechanical Systems Engineering				2		
	IMAC-G Special Seminar on Mechanical Systems Engineering				2		
専門科目 Major General Subjects	機械機能創成特別講義B Special Lecture on Mechanical Systems Engineering B				1～4		
	機械機能創成特別研修B Advanced Seminar on Mechanical Systems Engineering B				1～4		
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	機械機能創成博士研修 Doctor Course Seminar on Mechanical Systems and Engineering			8			

1．上記科目の単位数を合わせて16単位以上を修得すること。(自専攻の学際基盤科目から4単位以上履修すること。ただし、特別講義B、特別研修B及び他専攻・他研究科の関連科目の内から4単位以上を選択履修することもできる)

Students must acquire 16 or more credits from the subjects above.(Students must acquire 4 or more credits from the Interdisciplinary Basic subjects of their own department, and can also select 4 or more credits from Special Lecture on Mechanical Systems Engineering B, Advanced Seminar on Mechanical Systems Engineering B and Related subjects of other departments or other schools.)

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)

Management of Research and Development 2 credits

Elective Required
Professor Hideo Miura
Professor Yutaka Watanabe

The important skills for the effective and rational management of research and development in scientific and technological fields are lectured. Most important issue is how to propose a new R&D project for the human societies near future. Not only the personal skills but also the trend of the science and technology policies all over the world will be discussed. Group discussion for proposing a new R&D project is the most important part of this intensive course for training the management skill of each student. Students are expected to learn the basic important way of thinking for the management of research and development project from the viewpoints of top leader, middle manager, and personal researcher. The most important issue is to be aware of indispensable skills which each student should improve during her/his student life to be a leader of a certain research project near future. This intensive course consists of 3 days. Group discussion often continues to midnight of the second day. Students are expected to attend the three-straight-day course fully.

History of Modern Technology 2 credits

Elective Required
Professor Shuji Tanaka

Learning the history of technology leads to understanding the origin and genealogy of the technology, the inevitable factors of technological development, the relationship between society and the technology, the process and consequence of try-and-errors, the successes and failures of engineers and researchers etc. This intensive class introduces the development and partially decline of familiar devices and technologies such as automobile engines, memory devices, communication tools and semiconductor integrated circuits. The history of each technology includes the philosophy and lessons which are also useful for other research and development, and thus attendee are expected to consider them for their doctoral theses and future research and development. The lectures are partially given by visiting lecturers, and fully given in Japanese.

Venture Management 2 credits

Elective Required
Professor Shuichi Ishida

Venture Strategy 2 credits

Elective Required

Advanced Intelligent Design 2 credits

Elective Required
Professor Tsunemoto Kuriyagawa
Professor Takahito Ono
Associate Professor Masayoshi Mizutani

Nanotechnology-based nano-precision mechanical manufacturing and micro-nanomachining, and integration technologies of various components are lectured. Precision machines based on above technologies and micro-nanomachines, the design and modeling of those mechanical elements, recent researches on applications to information technologies, energy, and medical fields are also lectured.

Advanced Energy Systems Engineering 2 credits

Elective Required
Professor Hiroo Yugami
Professor Tetsushi Biwa
Professor Masaya Shigeta

This course provides students with deep knowledge on the broad topics selected from energy conversion engineering and related fields, such as the control and application methods of heat and fluid energy, as well as renewable energy technology and thermoacoustics. Emphasis is placed on improvement of the students' ability to find out the problems and to pursue the solutions.

Fracture Mechanics and Mechanisms 2 credits

Elective Required
Professor Kazuhiro Ogawa
Associate Professor Yoichi Takeda

Although a fracture is a well-known phenomenon since early times, the unsolved problem has been left because of the diversity of the influential factors. Therefore, the elucidation of fracture mechanics and mechanisms are desired.
For the elucidation of fracture mechanics and mechanisms, it is necessary that understanding of the interaction and synergistic effect of the diversified influential factors.
In this lecture, fractures of the structures, which are induced by high-temperature oxidation and the environmental assisted cracking, are lectured. Moreover, examples of failure accidents in structures and materials are introduced, its suppression and prevention techniques are discussed.

Intelligent Fluid Systems 2 credits

Elective Required
Professor Kaoru Maruta
Professor Takehiko Sato
Professor Atsuki Komiya

Fundamentals and applications for intelligent control of thermo-fluid flows under the various conditions including microgravity and electro-magnetic field, and its optimized simulation method are discussed. The construction of intelligent fluid systems with sensing, processing, control and actuation and its applications to energy conversion, plasma medicine and material processing are discussed.
Prof. K. Maruta: Fundamental and applications of combustion dynamics
Prof. T. Sato: Plasma medicine and plasma flows
Prof. A. Komiya: Sensing and control of micro-nano scale thermos-fluid flows

Advanced Mechanical Systems Maintenance Engineering 2 credits Elective Required Professor Tetsuya Uchimoto Associate Professor Hiroyuki Miki Maintenance activities play an important role to secure the safety and long-life of various artifacts such as industrial plants, commercial aircrafts. 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 recent progresses of disciplines composing maintenance engineering such as reliability engineering, risk evaluation, nondestructive testing, failure analysis, at first. In addition, we discuss the quantitative evaluation of reliability and risk for optimization of the maintenance activities such as inspection and repair.	**Multidisciplinary Research and Application of Solid-State Ionic Devices** 2 credits Elective Required Professor Koji Amezawa In this lecture, topics related to basics and applications of ion transport phenomena in solids and on solid surface and/or interface are introduced and discussed from the viewpoints of materials chemistry and solid state physics. More details, such as the style of the lecture, will be announced in the beginning of the semester.
Advanced Nano/Technology 2 credits Elective Required Professor Gao Wei Professor Koshi Adachi	**Advanced Bio-Nanotechnology** 2 credits Elective Required Professor Matsuhiko Nishizawa Professor Tetsu Tanaka Associate Professor Takafumi Fukushima Recent trends and perspective on Bio-nanotechnology, including the progress in micromachining techniques and LSI techniques, will be lectured in order to educate ability for engineering innovative devices for advanced medicines.
Advanced Mechanical System and Design 2 credits Elective Required Professors of Mechanical Systems Engineering This course is prepared for learning various subjects and topics related to the specific field of Mechanical Systems Engineering. The scope covers wide fields related to mechanical system technologies, including intelligent system, engineering design, energy system, and multidisciplinary fields.	**IMAC-G Special Seminar on Mechanical Systems Design** 2 credits Elective Required This seminar is prepared for learning various subjects and topics related to the specific field of the course.
Special Lecture on Mechanical Systems Engineering B 1~4 credits Elective Required 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 B** 1~4 credits Elective Required The problem-posing ability is acquired by integrating advanced expertise through the training.
Doctor Course Seminar on Mechanical Systems and Engineering 8 credits Required Students engage in experiments and seminars, including research presentations, discussion and literature reviews.	

授業科目表（DC） List of courses

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	
学際基盤科目 Interdisciplinary Basic Subjects	研究開発マネージメント論 Manageement of Research and Development	毎年 Every year	JE		2		左記の学際基盤科目，特別講義B，特別研修B，及び関連科目の内から4科目以上を選択履修し，8単位以上を修得すること．なお，特別講義Bと特別研修B及び関連科目で修得した単位は4単位まで本要件に含めることができる． A student has to earn 8 or more credits from the Interdisciplinary basic subjects listed in the left column. However, a total of 4 credits at most, obtained from Advanced seminar B, Special lecture B,and Related subjects are included in this requirement.
	近代技術史学 History of Modern Technology	毎年 Every year	J		2		
	ベンチャー・ビジネス論 Venture Management	毎年 Every year	J		2		
	ベンチャー企業戦略 Venture Strategy		J		2		
	ナノフォトニックメカニカルシステム Nano-Photonic Mechanical Systems	隔年 Every second year	E		2		
	材料メカニクス特論 Advanced Mechanics of Materials	隔年 Every second year	E		2		
	ナノテクノロジー特論 Advanced Nano/Technology		E		2		
	先端材料強度科学特論 Strength and Reliability of Advanced Materials	毎年 Every year	E		2		
	ナノ流動学特論 Nano-Flow Science	隔年 Every second year	E		2		
	知能システム工学特論 Advanced Intelligence and Systems Engineering		E		2		
	破壊機構学特論 Fracture Mechanics and Mechanisms	毎年 Every year	E		2		
	バイオナノテクノロジー特論 Advanced Bio-Nanotechnology	隔年 Every second year	E		2		
	バイオメカニクス特別講義Ⅱ Special Lecture Series on Integrated Biomechanics Ⅱ		E		2		
	知的メカノシステム工学特論 Intelligent Mechanosystem Engineering		E		2		
	表面ナノ・マイクロ計測制御学特論 Advanced Nano-and Micro-Surface Metrology and Engineering	隔年 Every second year	E		2		
	Advanced Finemechanics				2		
	IMAC-G Special Seminar on Finemechanics				2		
専門科目 Major General Subjects	ファインメカニクス特別講義B Special Lecture on Finemechanics B				1～4		
	ファインメカニクス特別研修B Advanced Seminar on Finemechanics B				1～4		
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	ファインメカニクス博士研修 Doctor Course Seminar on Finemechanics			8			

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Students must acquire 16 or more credits from the subjects above.(Students must acquire 4 or more credits from the Interdisciplinary Basic subjects of their own department, and can also select 4 or more credits from Special Lecture on Finemechanics B, Advanced Seminar on Finemechanics B and Related subjects of other departments or other schools.)

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Management of Research and Development 2 credits

Elective Required
Professor Hideo Miura
Professor Yutaka Watanabe

The important skills for the effective and rational management of research and development in scientific and technological fields are lectured. Most important issue is how to propose a new R&D project for the human societies near future. Not only the personal skills but also the trend of the science and technology policies all over the world will be discussed. Group discussion for proposing a new R&D project is the most important part of this intensive course for training the management skill of each student. Students are expected to learn the basic important way of thinking for the management of research and development project from the viewpoints of top leader, middle manager, and personal researcher. The most important issue is to be aware of indispensable skills which each student should improve during her/his student life to be a leader of a certain research project near future. This intensive course consists of 3 days. Group discussion often continues to midnight of the second day. Students are expected to attend the three-straight-day course fully.

History of Modern Technology 2 credits

Elective Required
Professor Shuji Tanaka

Learning the history of technology leads to understanding the origin and genealogy of the technology, the inevitable factors of technological development, the relationship between society and the technology, the process and consequence of try-and-errors, the successes and failures of engineers and researchers etc. This intensive class introduces the development and partially decline of familiar devices and technologies such as automobile engines, memory devices, communication tools and semiconductor integrated circuits. The history of each technology includes the philosophy and lessons which are also useful for other research and development, and thus attendee are expected to consider them for their doctoral theses and future research and development. The lectures are partially given by visiting lecturers, and fully given in Japanese.

Venture Management 2 credits

Elective Required
Professor Shuichi Ishida

Venture Strategy 2 credits

Elective Required

Nano-Photonic Mechanical Systems 2 credits

Elective Required
Professor Yoshiaki Kanamori

The research field of Mechanical engineering extends to micro/nano scale science and technology. Optical technology is indispensable for investigation and control in micro/nano regions. In this lecture, interactions between photons and atoms/molecules, principles of lasers and their systems, and photonic devices using nano/micro structures are explained and discussed.

Advanced Mechanics of Materials 2 credits

Elective Required
Professor Hitoshi Soyama
Professor Hironori Tomyoh

Lecture will deal with methodological explorations about extension of life time and enhancement of strength of various materials systems from small systems such as IC packages to large mechanical components and structures, in order to use the systems at severe conditions and/or long time. Microscopic key factors of functional characteristics and performance of the systems are variety of atoms and molecules, their sequences in nanoscale and microstructure in meso-scale. On the basis of these factors, analysis of microscopic characteristics and effects of the microscopic characteristics on macroscopic characteristics will be reviewed including their measurement and evaluation methods, and some real examples will be described in the lecture.

Advanced Nano/Technology 2 credits

Elective Required
Professor Gao Wei
Professor Koshi Adachi

Strength and Reliability of Advanced Materials 2 credits

Elective Required
Professor Hideo Miura

This course gives students important hints for designing highly functional and highly reliable thin-film devices based on the discussion of the reason for the wide variation of physical and chemical properties of thin-film materials and how to control them. Main topics are as follows. 1) Nano- and Micro-texture-induced variation and fluctuation of physical and chemical properties of materials, 2) Crystallinity-induced changes of electronic and optical performances of thin-film devices, and 3) Degradation of the performances due to the strain-induced anisotropic acceleration of atomic diffusion of component elements in materials.

Nano-Flow Science 2 credits

Elective Required
Professor Seiji Samukawa
Professor Takashi Tokumasu

To realize higher performance and lower energy consumption of advanced green nano-devices such as ULSI, TFT, MEMS/NEMS, sensors, optical devices, solar cells, secondary batteries, thermoelectric conversion devices, and so on, a process technology with atomic-layer-level control of device materials and structure is inevitable. Process technologies (such as etching, thin film deposition, surface modification) are basis of nanotechnology and are realized by utilization and control of plasma, beam, bio-molecules, and so on. This course will introduce the principle of these nano-processes which is needed for research and development of green nano-devices. Examples of devices fabricated by these processes are also introduced.

Advanced Intelligence and Systems Engineering
2 credits

Elective Required
Professor Kazuo Hokkirigawa
Associate Professor Takeshi Yamaguchi

In order to realize significant increase in performance of mechanical systems such as micro-machine, robots, and space equipment, it is necessary to develop new materials and to establish new design approaches using the materials. This course will provide all students with the fundamental technologies for material development and the advanced knowledge and concept associated with intelligence and systems engineering.

Fracture Mechanics and Mechanisms 2 credits

Elective Required
Professor Kazuhiro Ogawa
Associate Professor Yoichi Takeda

Although a fracture is a well-known phenomenon since early times, the unsolved problem has been left because of the diversity of the influential factors. Therefore, the elucidation of fracture mechanics and mechanisms are desired.
For the elucidation of fracture mechanics and mechanisms, it is necessary that understanding of the interaction and synergistic effect of the diversified influential factors.
In this lecture, fractures of the structures, which are induced by high-temperature oxidation and the environmental assisted cracking, are lectured. Moreover, examples of failure accidents in structures and materials are introduced, its suppression and prevention techniques are discussed.

Advanced Bio-Nanotechnology 2 credits

Elective Required
Professor Matsuhiko Nishizawa
Professor Tetsu Tanaka
Associate Professor Takafumi Fukushima

Recent trends and perspective on Bio-nanotechnology, including the progress in micromachining techniques and LSI techniques, will be lectured in order to educate ability for engineering innovative devices for advanced medicines.

Special Lecture Series on Integrated Biomechanics II
2 credits

Elective Required
Professor Yoichi Haga
Professor Takuji Ishikawa
Professor Makoto Ohta
Associate Professor Makoto Kanzaki

Intelligent Mechanosystem Engineering 2 credits

Elective Required
Professor Makoto Ohta
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 summarize contents of Intelligent mechano-system Analysis in Masters course focused on the basic concepts of function spaces and optimization theory in Hilbert space, and then study basic concepts to understand more general optimization theories in Banach space such as dual spaces, linear operators, adjoints, from intuitive geometrical point of view.

Advanced Nano-and Micro-Surface Metrology and Engineering 2credits

Elective Required
Professor Wataru Yashiro

Measurement and control are the two wheels of manufacturing. The aim of this lecture is to learn the most advanced measurement and control methods covering a wide range of spatial scales from atomic to macroscopic scales of surfaces and interfaces that govern the functions of materials. The ultimate goal of this course is to enable students to gain insight into the current state of measurement and control technology, its limitations, and the potential for opening up new frontiers in materials and life sciences.

Advanced Finemechanics 2 credits

Elective Required
Professors of Finemechanics

This course is prepared for learning various subjects and topics related to the specific field of Finemechanics.

IMAC-G Special Seminar on Mechanical Systems and Design 2 credits Elective Required This seminar is prepared for learning various subjects and topics related to the specific field of the course.	**Special Lecture on Finemechanics B** 1~4 credits Elective Required 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 B 1~4 credits Elective Required The problem-posing ability is acquired by integrating advanced expertise through the training.	**Doctor Course Seminar on Finemechanics** 8 credits Required Students engage in experiments and seminars, including research presentations, discussion and literature reviews.

授業科目表（DC） List of courses

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	
学際基盤科目 Interdisciplinary Basic Subjects	研究開発マネージメント論 Managegement of Research and Development	毎年 Every year	JE		2		左記の学際基盤科目，特別講義B，特別研修B，及び関連科目の内から4科目以上を選択履修し，8単位以上を修得すること．なお，特別講義Bと特別研修B及び関連科目で修得した単位は4単位まで本要件に含めることができる． A student has to earn 8 or more credits from the Interdisciplinary basic subjects listed in the left column. However, a total of 4 credits at most, obtained from Advanced seminar B, Special lecture B,and Related subjects are included in this requirement.
	近代技術史学 History of Modern Technology	毎年 Every year	J		2		
	ベンチャー・ビジネス論 Venture Management	毎年 Every year	J		2		
	ベンチャー企業戦略 Venture Strategy		J		2		
	バイオナノテクノロジー特論 Advanced Bio-Nanotechnology	隔年 Every second year	E		2		
	バイオメカニクス特別講義Ⅱ Special Lecture Series on Integrated Biomechanics Ⅱ		E		2		
	ロボティクス特論 Advanced Robotics	隔年 Every second year	E		2		
	知的メカノシステム工学特論 Intelligent Mechanosystem Engineering		E		2		
	知的デザイン学特論 Advanced Intelligent Design		E		2		
	ナノテクノロジー特論 Advanced Nano/Technology		E		2		
	Advanced Robotics				2		
	IMAC-G Special Seminar on Robotics				2		
専門科目 Major General Subjects	ロボティクス特別講義B Special Lecture on Robotics B				1～4		
	ロボティクス特別研修B Advanced Seminar on Robotics B				1～4		
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	ロボティクス博士研修 Doctor Course Seminar on Robotics			8			

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Students must acquire 16 or more credits from the subjects above.(Students must acquire 4 or more credits from the Interdisciplinary Basic subjects of their own department, and can also select 4 or more credits from Special Lecture on Robotics B, Advanced Seminar on Robotics B and Related subjects of other departments or other schools.)

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Management of Research and Development 2 credits

Elective Required
Professor Hideo Miura
Professor Yutaka Watanabe

The important skills for the effective and rational management of research and development in scientific and technological fields are lectured. Most important issue is how to propose a new R&D project for the human societies near future. Not only the personal skills but also the trend of the science and technology policies all over the world will be discussed. Group discussion for proposing a new R&D project is the most important part of this intensive course for training the management skill of each student. Students are expected to learn the basic important way of thinking for the management of research and development project from the viewpoints of top leader, middle manager, and personal researcher. The most important issue is to be aware of indispensable skills which each student should improve during her/his student life to be a leader of a certain research project near future. This intensive course consists of 3 days. Group discussion often continues to midnight of the second day. Students are expected to attend the three-straight-day course fully.

History of Modern Technology 2 credits

Elective Required
Professor Shuji Tanaka

Learning the history of technology leads to understanding the origin and genealogy of the technology, the inevitable factors of technological development, the relationship between society and the technology, the process and consequence of try-and-errors, the successes and failures of engineers and researchers etc. This intensive class introduces the development and partially decline of familiar devices and technologies such as automobile engines, memory devices, communication tools and semiconductor integrated circuits. The history of each technology includes the philosophy and lessons which are also useful for other research and development, and thus attendee are expected to consider them for their doctoral theses and future research and development. The lectures are partially given by visiting lecturers, and fully given in Japanese.

Venture Management 2 credits

Elective Required
Professor Shuichi Ishida

Venture Strategy 2 credits

Elective Required

Advanced Bio-Nanotechnology 2 credits

Elective Required
Professor Matsuhiko Nishizawa
Professor Tetsu Tanaka
Associate Professor Takafumi Fukushima

Recent trends and perspective on Bio-nanotechnology, including the progress in micromachining techniques and LSI techniques, will be lectured in order to educate ability for engineering innovative devices for advanced medicines.

Special Lecture Series on Integrated Biomechanics II 2 credits

Elective Required
Professor Yoichi Haga
Professor Takuji Ishikawa
Professor Makoto Ohta
Associate Professor Makoto Kanzaki

Advanced Robotics 2 credits

Elective Required
Professor Satoshi Murata
Professor Shuji Tanaka
Professor Yasuhisa Hirata
Professor Mitsuhiro Hayashibe
Professor Yoshiaki Kanamori
Professor Yoichi Haga
Professor Mami Tanaka

Intelligent Mechanosystem Engineering 2 credits

Elective Required
Professor Makoto Ohta
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 summarize contents of Intelligent mechano-system Analysis in Masters course focused on the basic concepts of function spaces and optimization theory in Hilbert space, and then study basic concepts to understand more general optimization theories in Banach space such as dual spaces, linear operators, adjoints, from intuitive geometrical point of view.

Advanced Intelligent Design 2 credits Elective Required Professor Tsunemoto Kuriyagawa Professor Takahito Ono Associate Professor Masayoshi Mizutani Nanotechnology-based nano-precision mechanical manufacturing and micro-nanomachining, and integration technologies of various components are lectured. Precision machines based on above technologies and micro-nanomachines, the design and modeling of those mechanical elements, recent researches on applications to information technologies, energy, and medical fields are also lectured.	**Advanced Nano/Technology** 2 credits Elective Required Professor Gao Wei Professor Koshi Adachi
Advanced Robotics 2 credits Elective Required Professors of Robotics This course is prepared for learning various subjects and topics related to the specific field of Robotics.	**IMAC-G Special Seminar on Bioengineering and Robotics** 2 credits Elective Required This seminar is prepared for learning various subjects and topics related to the specific field of the course.
Special Lecture on Robotics B 1~4 credits Elective Required 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 Robotics B** 1~4 credits Elective Required The problem-posing ability is acquired by integrating advanced expertise through the training.
Doctor Course Seminar on Robotics 8 credits Required Students engage in experiments and seminars, including research presentations, discussion and literature reviews.	

授業科目表(DC) List of courses

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	
学際基盤科目 Interdisciplinary Basic Subjects	研究開発マネージメント論 Managegement of Research and Development	毎年 Every year	JE		2		左記の学際基盤科目，特別講義B，特別研修B，及び関連科目の内から4科目以上を選択履修し，8単位以上を修得すること．なお，特別講義Bと特別研修B及び関連科目で修得した単位は4単位まで本要件に含めることができる． A students has to earn 8 or more credits from the Interdisciplinary basic subjects listed in the left column. However, a total of 4 credits at most, obtained from Advanced seminar B , Special lecture B,and Related subjects are included in this requirement.
	近代技術史学 History of Modern Technology	毎年 Every year	J		2		
	ベンチャー・ビジネス論 Venture Management	毎年 Every year	J		2		
	ベンチャー企業戦略 Venture Strategy		J		2		
	航空システム特論 Ⅰ Advanced Aero Systems Ⅰ		E		2		
	航空システム特論 Ⅱ Advanced Aero Systems Ⅱ		E		2		
	宇宙システム特論 Ⅰ Advanced Space Systems Ⅰ	毎年 Every year	E		2		
	宇宙システム特論 Ⅱ Advanced Space Systems Ⅱ	毎年 Every year	E		2		
	航空宇宙流体工学特論 Advanced Space Fluid Dynamics		E		2		
	Advanced Aerospace Engineering				2		
	IMAC-G Special Seminar on Aerospace Engineering				2		
専門科目 Major General Subjects	航空宇宙工学特別講義B Special Lecture on Aerospace Engineering B				1～4		
	航空宇宙工学特別研修B Advanced Seminar on Aerospace Engineering B				1～4		
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	航空宇宙工学博士研修 Doctor Course Seminar on Aerospace Engineering			8			

1．上記科目の単位数を合わせて16単位以上を修得すること。(自専攻の学際基盤科目から4単位以上履修すること。ただし、特別講義B、特別研修B及び他専攻・他研究科の関連科目の内から4単位以上を選択履修することもできる)

Students must acquire 16 or more credits from the subjects above.(Students must acquire 4 or more credits from the Interdisciplinary Basic subjects of their own department, and can also select 4 or more credits from Special Lecture on Aerospace Engineering B, Advanced Seminar on Aerospace Engineering B and Related subjects of other departments or other schools.)

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)

Management of Research and Development 2 credits Elective Required Professor Hideo Miura Professor Yutaka Watanabe The important skills for the effective and rational management of research and development in scientific and technological fields are lectured. Most important issue is how to propose a new R&D project for the human societies near future. Not only the personal skills but also the trend of the science and technology policies all over the world will be discussed. Group discussion for proposing a new R&D project is the most important part of this intensive course for training the management skill of each student. Students are expected to learn the basic important way of thinking for the management of research and development project from the viewpoints of top leader, middle manager, and personal researcher. The most important issue is to be aware of indispensable skills which each student should improve during her/his student life to be a leader of a certain research project near future. This intensive course consists of 3 days. Group discussion often continues to midnight of the second day. Students are expected to attend the three-straight-day course fully.	**History of Modern Technology** 2 credits Elective Required Professor Shuji Tanaka Learning the history of technology leads to understanding the origin and genealogy of the technology, the inevitable factors of technological development, the relationship between society and the technology, the process and consequence of try-and-errors, the successes and failures of engineers and researchers etc. This intensive class introduces the development and partially decline of familiar devices and technologies such as automobile engines, memory devices, communication tools and semiconductor integrated circuits. The history of each technology includes the philosophy and lessons which are also useful for other research and development, and thus attendee are expected to consider them for their doctoral theses and future research and development. The lectures are partially given by visiting lecturers, and fully given in Japanese.
Venture Management 2 credits Elective Required Professor Shuichi Ishida	**Venture Strategy** 2 credits Elective Required
Advanced Aero Systems I 2 credits Elective Required Professor Keisuke Asai Professor Tomonaga Okabe Professor Soshi Kawai This course covers computational methods used in aerospace engineering problems and includes the following topics: 1. Introduction to the continuum mechanics for the application of structural analysis and computational fluid dynamics 2. Finite element methods for structural analysis and nonlinear problems. 3. Mathematical foundations of modern computational fluid dynamics and the application to aircraft design processes. 4. Mathematical formulation of multidisciplinary design problems and overview of gradient-based and gradient-free algorithms. 5. Dynamic mode decomposition for modelling of complex and interactive problems.	**Advanced Aero Systems II** 2 credits Elective Required Professor Keisuke Asai Professor Tomonaga Okabe Professor Soshi Kawai This course provides the topics of advanced fluid mechanics researches in aerospace engineering and its related fields, such as aircraft aerodynamic design processes, etc., to study the existing advanced knowledge and remaining issues in the areas of fluid mechanics. The topics will broadly include numerical and experimental researches in fluid mechanics and also how the fluid mechanics researches apply to the aircraft design processes. Students are expected to acquire the ability of problem finding and setting as a doctoral course student through the various topics of fluid mechanics researches provided.

Advanced Space Systems I 2 credits Elective Required Professor Kazuya Yoshida Professor Naofumi Ohnishi Professor Kanjuro Makihara Associate Professor Toshinori Kuwahara This course covers advanced issues on space flight systems, which are useful for elaborating PhD level studies of space engineering: ・The scope of the course is the design, development, launch and operation of space flight systems for Earth-orbiting missions and/or interplanetary missions. ・Depending on the availability of the lecturers, a specific focus will be made on the topics from propulsion systems, space structures, orbital mechanics, attitude dynamics and control, and space robotics. ・Lectures can be conducted by invited international lectures. ・All lectures are given in English.	**Advanced Space Systems II** 2 credits Elective Required Professor Kazuya Yoshida Professor Naofumi Ohnishi Professor Kanjuro Makihara Associate Professor Toshinori Kuwahara This course provides extensive advanced lectures on space flight systems, particularly the issues not covered by Advanced Space Systems I: ・The scope of the course is the design, development, launch and operation of space flight systems for Earth-orbiting missions and/or interplanetary missions. ・Depending on the availability of the lecturers, a specific focus will be made on the topics from propulsion systems, space structures, orbital mechanics, attitude dynamics and control, and space robotics. ・Lectures can be conducted by invited international lectures. ・All lectures are given in English.
Advanced Space Fluid Dynamics 2 credits Elective Required Professor Hiroki Nagai Professor Shigeru Obayashi Professor Hideaki Kobayashi From the aerospace engineering and the related fields, this lecture delivers extensive and deep technical knowledge about the extreme flows such as the hypersonic flow, propulsion of the spacecraft, flows with various flights, supersonic combustion. The principal objective of the lecture is the cultivation of the ability of the doctoral course students for problem discovery and proposition of a new solution method.	**Advanced Aerospace Engineering** 2 credits Elective Required Professors of Aerospace Engineering This course is prepared for learning various subjects and topics related to the specific field of Aerospace Engineering.
IMAC-G Special Seminar on Aerospace Engineering 2 credits Elective Required This seminar is prepared for learning various subjects and topics related to the specific field of the course.	**Special Lecture on Aerospace Engineering B** 1~4 credits Elective Required 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 B 1~4 credits Elective Required The problem-posing ability is acquired by integrating advanced expertise through the training.	**Doctor Course Seminar on Aerospace Engineering** 8 credits Required Students engage in experiments and seminars, including research presentations, discussion and literature reviews.

授業科目表(DC) List of courses

量子エネルギー工学専攻
Department of Quantum Science and 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	
学際基盤科目 Interdisciplinary Basic Subjects	研究開発マネージメント論 Managegement of Research and Development	毎年 Every year	JE		2		左記の学際基盤科目，工学特別セミナー，特別講義B，特別研修B，及び関連科目の内から4科目以上を選択履修し，8単位以上を修得すること．なお，工学特別セミナー，特別講義，特別研修B及び関連科目で修得した単位は4単位まで本要件に含めることができる． A students has to earn 8 or more credits from the left column. However, a total of 4 credits at most, obtained from Special Seminar on Engineering, Special Lecture on Quantum Energy Engineering B, Special Seminar on Quantum Energy Engineering B and Related subjects are included in this requirement.
	近代技術史学 History of Modern Technology	毎年 Every year	J		2		
	ベンチャー・ビジネス論 Venture Management	毎年 Every year	J		2		
	ベンチャー企業戦略 Venture Strategy		J		2		
	先進量子エネルギー工学特論 Advanced Quantum Energy Engineering	毎年 Every year	J		2		
	先進原子核工学特論 Advanced Nuclear Engineering		JE		2		
	原子核システム安全工学特論 Advanced Safety Engineering of Nuclear Systems	毎年 Every year	J		2		
	エネルギー物理工学特論 Advanced Energy Physics Engineering		JE		2		
	粒子ビーム工学特論 Advanced Particle Beam Engineering		JE		2		
	エネルギー材料工学特論 Advanced Energy Material Engineering		JE		2		
	エネルギー化学工学特論 Advanced Energy Chemical Engineering	隔年 Every second year	JE		2		
	量子物性工学特論 Advanced Quantum Material Engineering		JE		2		
	加速器放射線工学特論 Advanced Accelerator and Radiation Engineering		JE		2		
	量子エネルギー工学特論 Advanced Quantum Science and Energy Engineering		E		2		
	Advanced Quantum Science and Engineering						
	IMAC-G Special Seminar on Quantum Science and Engineering						
専門科目 Major General Subjects	工学特別セミナー Special Seminar on Engineering		J		2		
	量子エネルギー工学特別講義B Special Lecture on Quantum Energy Engineering B				1～4		
	量子エネルギー工学特別研修B Special Seminar on Quantum Energy Engineering B				1～4		
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	量子エネルギー工学博士研修 Doctor Course Seminar on Quantum Energy Engineering			8			

1．上記科目の単位数を合わせて16単位以上を修得すること。(自専攻の学際基盤科目から4単位以上履修すること。ただし、工学特別セミナー、特別講義B、特別研修B及び他専攻・他研究科の関連科目の内から4単位以上を選択履修することもできる)

Students must acquire 16 or more credits from the subjects above.(Students must acquire 4 or more credits from the Interdisciplinary Basic subjects of their own department, and can also select 4 or more credits from Special Seminar on Engineering, Special Lecture on Quantum Energy Engineering B, Special Seminar on Quantum Energy Engineering B and Related subjects of other departments or other schools.)

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。
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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)

Management of Research and Development 2 credits

Elective Required
Professor Hideo Miura
Professor Yutaka Watanabe

The important skills for the effective and rational management of research and development in scientific and technological fields are lectured. Most important issue is how to propose a new R&D project for the human societies near future. Not only the personal skills but also the trend of the science and technology policies all over the world will be discussed. Group discussion for proposing a new R&D project is the most important part of this intensive course for training the management skill of each student. Students are expected to learn the basic important way of thinking for the management of research and development project from the viewpoints of top leader, middle manager, and personal researcher. The most important issue is to be aware of indispensable skills which each student should improve during her/his student life to be a leader of a certain research project near future. This intensive course consists of 3 days. Group discussion often continues to midnight of the second day. Students are expected to attend the three-straight-day course fully.

History of Modern Technology 2 credits

Elective Required
Professor Shuji Tanaka

Learning the history of technology leads to understanding the origin and genealogy of the technology, the inevitable factors of technological development, the relationship between society and the technology, the process and consequence of try-and-errors, the successes and failures of engineers and researchers etc. This intensive class introduces the development and partially decline of familiar devices and technologies such as automobile engines, memory devices, communication tools and semiconductor integrated circuits. The history of each technology includes the philosophy and lessons which are also useful for other research and development, and thus attendee are expected to consider them for their doctoral theses and future research and development. The lectures are partially given by visiting lecturers, and fully given in Japanese.

Venture Management 2 credits

Elective Required
Professor Shuichi Ishida

Venture Strategy 2 credits

Elective Required

Advanced Quantum Energy Engineering 2 credits

Elective Required
Professor Makoto Takahashi
Associate Professor Daisuke Karikawa

The aim of this lecture is to understand practical methodology of risk assessment and management for large-scale complex socio-technical systems. The activities of traditional safety risk management are mainly reactive, meaning they focus on correcting defects after negative events occurred. This lecture, on the other hand, discusses proactive risk management methodology with emphasis on human-machine interaction, organizational issues, and the concepts of resilience engineering. The topics of this lecture also cover risk communication and engineering ethics.

Advanced Nuclear Engineering 2 credits

Elective Required
Professors of Quantum Science and Energy Engineering

In this course, we learn the most advanced particle beam technology such as a high current accelerator to enable the extinction of nuclear waste, the nano-beam technology to enable 3D nano-machining, photon factory to provide high intensity monochromatic X-rays, particle beam therapy, and its application technologies. The fundamentals on nano- and micro-beam formation technology, storage ring, high current particle acceleration, a medical application of accelerator are mainly lectured. Through this lecture, the ability to find, setup, analyze and solve problems is developed.

Advanced Safety Engineering of Nuclear Systems 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Yuichi Niibori
Professor Makoto Takahashi
Professor Noritake Yusa
A specially appointed professor Takayuki Aoki
Visiting Professor Masahiro Yamamoto

Advanced Energy Physics Engineering 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Tomohiko Iwasaki
Professor Kenji Tobita

This class provides advanced technology and its basic knowledge in terms of energy system and neutronics of fusion and fission reactors. Several forefront topics are introduced on the advanced reactor engineering, energy flow dynamics, neutron utilization and fusion plasma confinement to learn how to pick up crucial issues and then how to solve the problems.

Advanced Particle Beam Engineering 2 credits

Elective Required
Professor Akira Hasegawa
Professor Shigeo Natsuyama
Professor Atsuki Terakawa
Associate Professor Keitaro Hitomi
Associate Professor Seong-Yun Kim

This class provides basic concepts of interaction between energetic particles and materials based on physics of atomic displacement and nuclear transmutation behavior of energetic particles and atoms of the materials in nuclear power systems. Material development for the nuclear systems and their characteristics from the view point of materials science and engineering are explained.

Advanced Energy Material Engineering 2 credits

Elective Required
Professor Eiji Akiyama
Professor Ryuta Kasada

This lecture will provide the following topics:
1. Environemental effects of advanced energy materials and their fundamentals.
2. Irradiation effects of advanced energy materials and their fundamentals.
3. Advanced anaylisis and measurements of energy materials.

Advanced Energy Chemical Engineering 2 credits

Elective Required
Associate Professor Akira Kirishima
Visiting Associate Professor Masayuki Watanabe

Advanced Quantum Material Engineering 2 credits

Elective Required
Professor Yasuyoshi Nagai
Professor Dai Aoki

The state-of-the-art actinide physics and chemistry, radiation damage and the techniques to analyze the material properties, electronic and atomic structures will be reviewed as fundamentals of quantum material engineering.

Advanced Accelerator and Radiation Engineering
2 credits

Elective Required
Professor Hiroshi Watabe
Associate Professor Keitaro Hitomi

In order to develop effective utilization of accelerator radiation for engineering and medical purposes, specialized knowledge of radiation engineering based on radiation physics will be lectured, and advanced topics will be discussed in order to cultivate the ability to identify and solve problems related to accelerator and medical physics. Biological effects of radiation and protection methods for various accelerator facilities will be discussed in detail to ensure the safety of accelerator radiation, which is a prerequisite for the use of accelerators.

Advanced Quantum Science and Energy Engineering
2 credits

Elective Required
Professors of Quantum Science and Energy Engineering

This lecture will deal with the following topics.
1. The engineering and physics foundation, and innovative technologies of nuclear energy systems, safety systems, and recycling systems.
2. The engineering and physics foundation of advanced nuclear reactors, such as nuclear fusion and ADS.
3. The science and innovative technology for high loading energy.
4. Applied particle-beam technology.

Advanced Quantum Energy and Engineering 2 credits

Elective Required
Professors of Quantum Science and Energy Engineering

This course is prepared for learning various subjects and topics related to the specific field of Quantum Energy Engineering.

IMAC-G Special Seminar on Quantum Science and Engineering 2 credits

Elective Required

This seminar is prepared for learning various subjects and topics related to the specific field of the course.

Special Seminar on Engineering 2 credits

Elective Required

Special Lecture on Quantum Energy Engineering B
1~4 credits
Elective Required
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 Quantum Energy Engineering B

Elective Required
The problem-posing ability is acquired by integrating advanced expertise through the training.

Doctor Course Seminar on Quantum Energy Engineering
8 credits

Required
Students engage in experiments and seminars, including research presentations, discussion and literature reviews.

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.

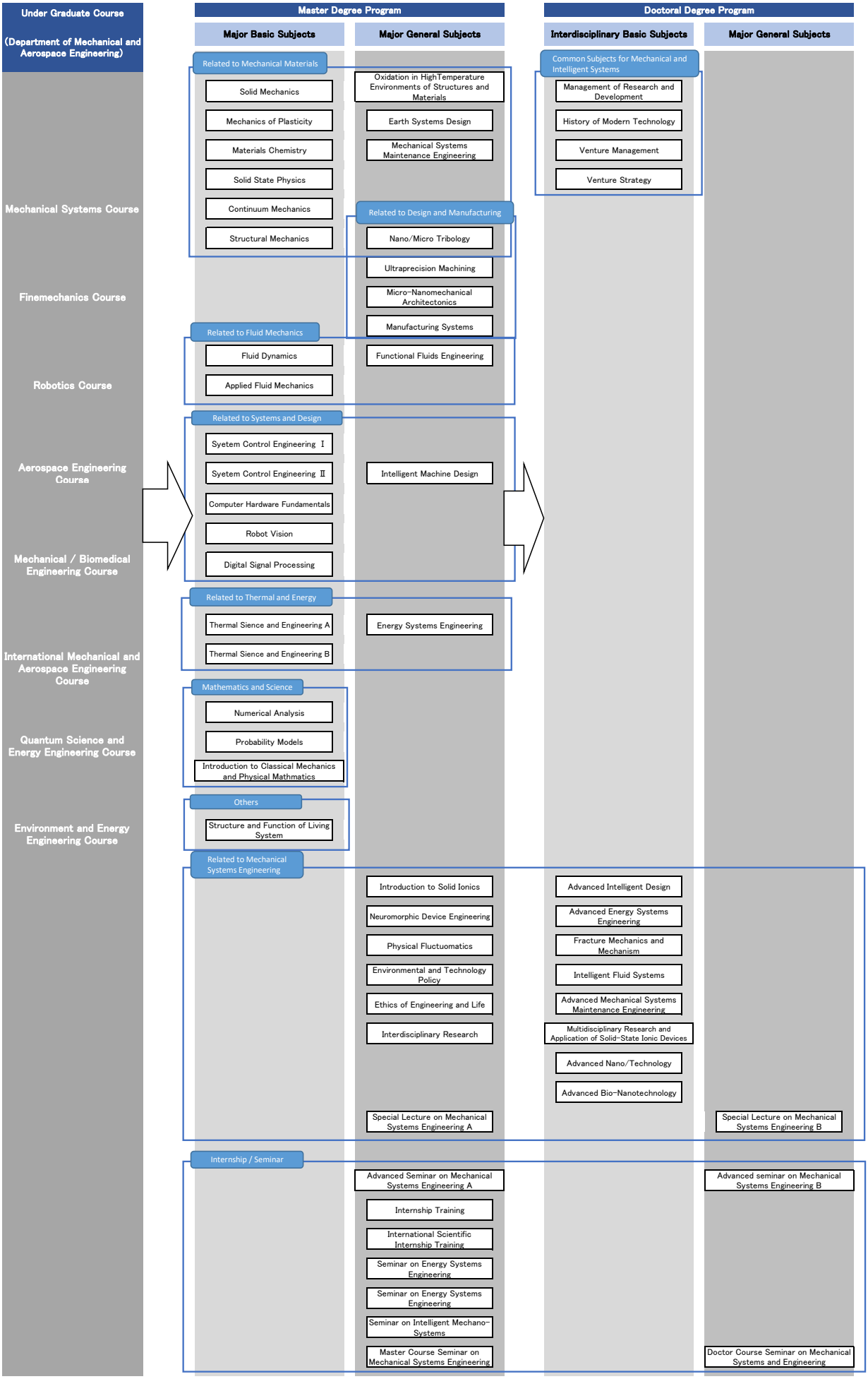
Classes are related each other, and unless you study them systematically from the basics to the advanced, you will not be able to truly understand and research the field. Please be aware of the connections and linkages between courses, and make a systematic course plan for the field of study you wish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

Grades may be written as follows;

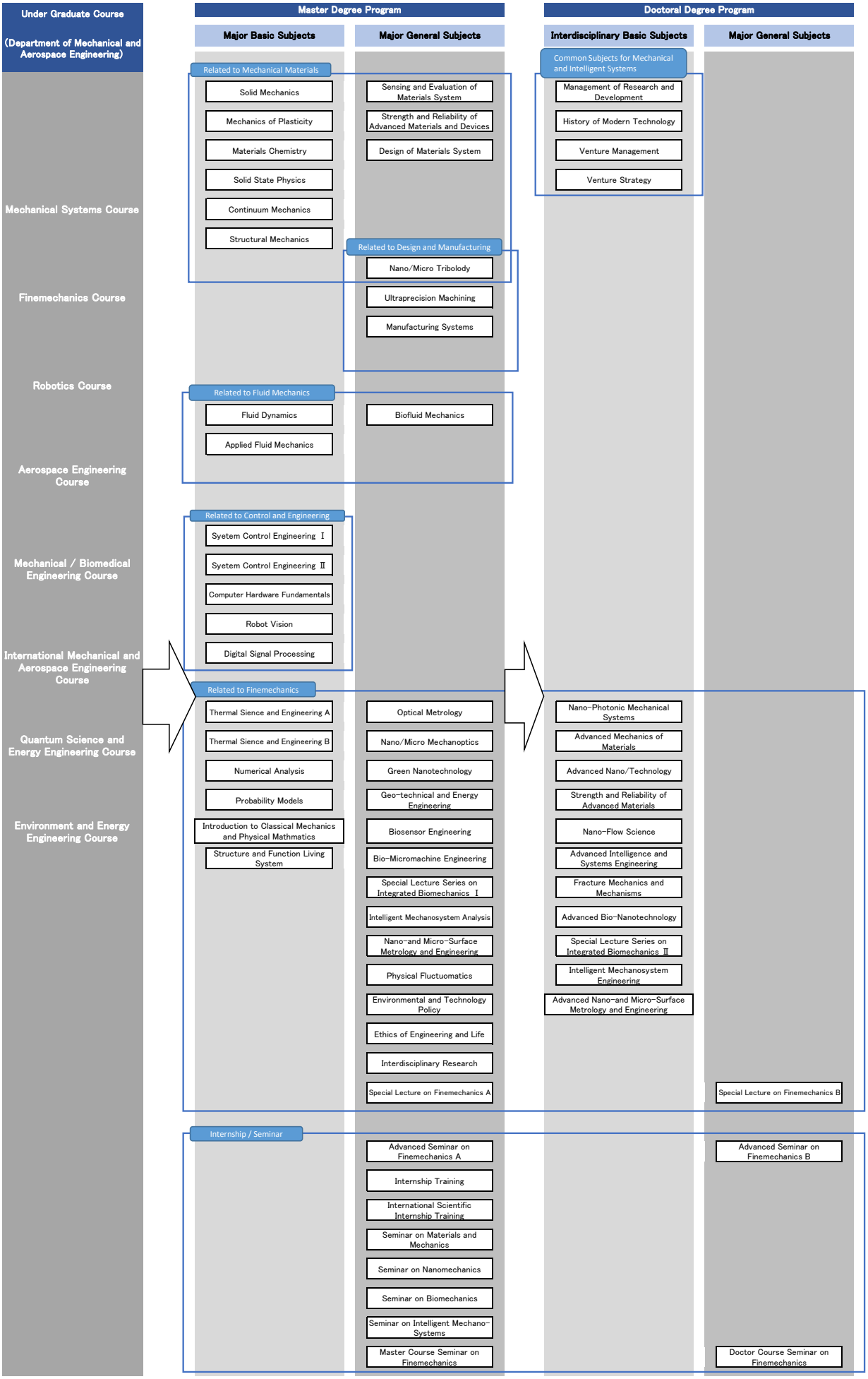
B1 First year Undergraduate student
B2 Second year Undergraduate student
B3 Third year Undergraduate student
B4 Forth year Undergraduate student

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

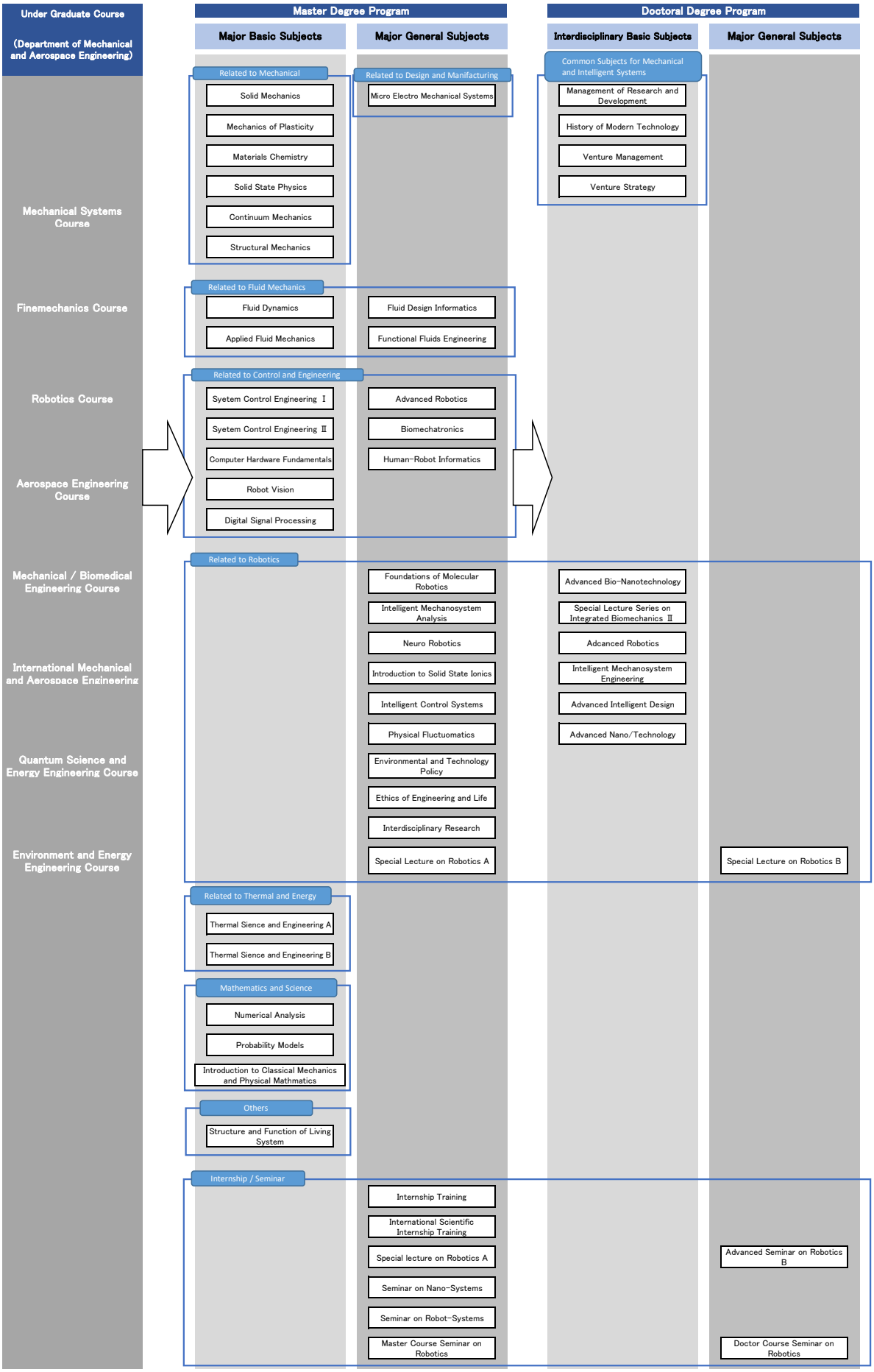
Department of Mechanical Systems Engineering



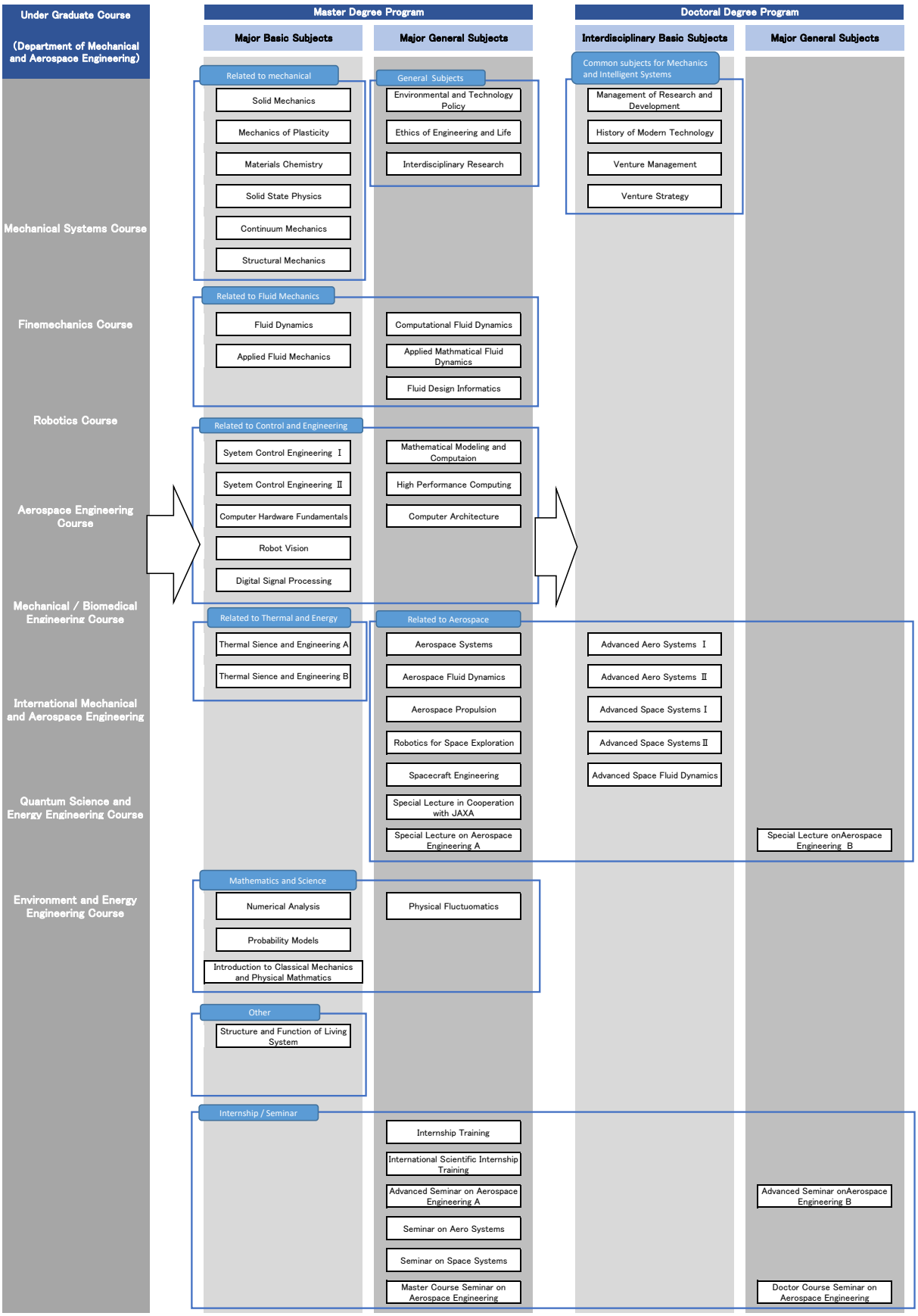
Department of Finemechanics



Department of Robotics



Department of Aerospace Engineering



Department of Quantum Science and Engineering