

**Tohoku University International Doctoral Program in  
Engineering, Information Sciences, Environmental Studies and Biomedical Engineering**

工学研究科、情報科学研究科、環境科学研究科、医工学研究科  
後期課程学際融合工学教育プログラム

Twenty-four students are admitted per year into the three course groups (eight students for each course group).

Lectures in English are arranged in various areas of concentration. Research supervision may be in English or Japanese depending on a student's language ability. Students may also attend lectures given in Japanese to fulfill their requirements.

Departments		
1. Mechanical Systems Engineering	11. Chemical Engineering	19. Computer and
2. Finemechanics	12. Biomolecular Engineering	Mathematical Sciences
3. Robotics	13. Metallurgy	20. System Information Sciences
4. Aerospace Engineering	14. Materials Science	21. Human-Social Information
5. Quantum Science and	15. Materials Processing	Sciences
Energy Engineering	16. Civil and	22. Applied Information Sciences
6. Electrical Engineering	Environmental Engineering	23. Environmental Studies for
7. Communications Engineering	17. Architecture and	Advanced Society
8. Electronic Engineering	Building Science	24. Frontier Sciences for Advanced
9. Applied Physics	18. Management Science and	Environment
10. Applied Chemistry	Technology	25. Biomedical Engineering

Students should also choose one from the following course groups (A-C):

Group A: Life Science

Group B: Green Innovation

Group C: Safety and Security

### DEGREE REQUIREMENTS

It depends on the rules of each Graduate School.

Students should complete the necessary credits according to degree requirements given by the department where they belong.

Example: Graduate School of Engineering (for students in the departments 1 through 18)

The main requirements for Ph.D. degree are (1) three years of residency, which may be shortened for special cases in which outstanding research performance is demonstrated; (2) successful completion of a minimum of 16 credits (3) submission of a Doctoral dissertation; and (4) oral defense of the dissertation.

Note that students should complete 2 or more credits of subjects provided by the course group (A/B/C) they chose, preferably by the department where they belong.

### 修了要件

各研究科の規程による。

修了するために必要な単位は、所属する専攻で定められている修了要件に従って修得しなければならない。

(例：工学研究科 1～18の専攻)

博士課程を修了するためには、後期課程に3年以上在学し、学際基盤科目、専門科目及び関連科目の単位数を合わせて16単位以上、かつ、必要な研究指導を受け、博士論文の審査及び最終試験に合格しなければならない。ただし、在学期間に関しては、本研究科委員会が別に定めるところにより、優れた研究業績を上げた者と認めた場合には、1年以上在学すれば足りるものとする。

また、所属するA～Cコースグループの授業科目を1科目2単位（指導教員の所属する専攻が開講する授業科目が望ましい。）以上選択履修すること。

Numbers in parentheses “( )” refer to departments offering the courses listed in page 1.

### Group A: Life Science

- (6)(25) Advanced Bioelectromagnetics (生体電磁工学特論/電エ, 医工学), to be determined  
(19) Advanced Topics in Neuroscience (神経科学の進歩/情報), 1st Semester, 2018  
(5)(25) Advanced Bio-Mechanics (バイオメカニクス特論/ロボ, 医工学), 2nd Semester, 2018  
(12) Advanced Biomolecular Engineering (応用生命化学特論/バ工), July and/or August, 2018  
(16) Advanced Environmental Hydraulics and Water Quality Engineering (水環境学特論/土木),  
July and/or August, 2019(Every other year)  
(4) Medical Molecular Engineering (分子医工学/量子), February and/or March, 2018

### Group B: Green Innovation

- (9) Quantum Material Physics (量子材料物理/応物), to be determined  
(11) Advanced Process Analysis and Modeling (プロセス解析工学特論/化工), July and/or August, 2020  
(17) CFD modeling for building environment design (建築環境デザインのための CFD モデリング/建築),  
April to July, 2018  
(18) Advanced Energy Systems and Society (エネルギー社会システム特論/技術),  
October,2017 to February, 2018  
(24) Advanced Eco-engineering Systems (環境物性化学特論/先端), August,2018  
(24) Advanced surface and subsurface measurements for environmental science (地球環境計測学特論/先端),  
August,2019  
(23) Advanced Studies on International Resource Strategy (国際資源戦略学特論/先進), August,2020  
(10) Advanced Course in Atoms and Molecules Control Engineering (原子・分子制御工学特論/応化),  
July and/or August, 2019  
(13) Advanced Course on Materials Physical Chemistry (材料理化学特論/金フ), July and/or August, 2019  
(14) Advanced Topics on Highly Sophisticated Materials (物性制御学特論/知材), July and/or August, 2019  
(14) Advanced Topics on High Performance Materials (高機能材料学特論/知材), July and/or August, 2019

### Group C: Safety and Security

- (3) Shock Wave in Complex Media and their Interdisciplinary Applications  
(複雑な媒体中の衝撃波とその応用/航空), July and/or August, 2018  
(16) Advanced Civil Engineering Structures (社会基盤構造学特論/土木),  
July and/or August, 2018(Every other year)  
(1)(2) Advanced Damage Tolerance and Design (損傷計測学特論/機械創成, ファイン), July and/or August, 2018  
(7)(8) Advanced High-Speed Communication Engineering (先端超高速情報工学/通信, 電子),  
April to September, 2018  
(13) Metallurgical Process Engineering (金属プロセス工学特論/金フ), July and/or August, 2018  
(4) Advanced Quantum Science and Energy Engineering (量子エネルギー工学特論/量子),  
August and/or September, 2019  
(8) Advanced Electronic Device Engineering (電子デバイス工学特論/電子), July and/or August, 2017  
(15) Advanced Materials Processing (材料システム工学特論/材シ), July and/or August, 2019  
(17) Geological Environment and Earthquake Disaster (地盤環境と地震災害/建築), July and/or August, 2019

Note: Please refer to “DEGREE REQUIREMENTS” in the previous pages.

**International Doctoral Program in  
Engineering, Information Sciences, Environmental Studies and Biomedical Engineering Syllabus  
for 2017 - 2019 COURSE GROUPS**

**Group A: Life Science**

<p>Name of Department: Department of Electrical Engineering and Department of Biomedical Engineering  Name of Lecture : <u>Advanced Bioelectromagnetics</u>  Schedule: to be determined  Instructors: to be determined</p> <p>Lecture: This lecture will deal with various aspects of bioelectromagnetics from basic knowledge to advanced subjects. Focus will be placed on overview of the health effects problem and on topics of biological effects and medical applications of electromagnetic fields and waves. Safety standards will be discussed.</p>
<p>Name of Department: Graduate School of Information Sciences  Name of lecture: <u>Advanced Topics in Neuroscience</u>  Schedule: 1st Semester, 2018  Instructors: Prof. Keichi Itoi, Assis. Prof. Tatsuya Sato, Assis. Prof. Katsuya Uchida</p> <p>Lecture: Neuroscience has made a remarkable progress owing to the development of molecular biology and genome science. This lecture will present some recent progress on neuroscience with the emphasis on neuroendocrinology. It will give an introduction of neuroendocrinology, neurophysiology, molecular engineering, and related neurological disorders. Possibly the lecture will have problem and solution session in which students should solve some exercises.</p>
<p>Name of Department: Department of Robotics and Department of Biomedical Engineering  Name of Lecture: <u>Advanced Bio-Mechanics</u>  Schedule: 2nd Semester, 2018  Instructors: Professors Yoichi Haga, Takuji Ishikawa, Makoto Ohta  Associate Professors Makoto Kanzaki</p> <p>Lecture: This course covers various aspects of biomechanics from basic knowledge to advanced subjects. Focus will be placed on several topics such as fluidics of blood and air, sensory systems, mechanics of soft and hard tissue.</p>
<p>Name of Department: Department of Biomolecular Engineering  Name of Lecture: <u>Advanced Biomolecular Engineering</u>  Schedule: July and/or August, 2018  Instructors: Professors Toru Nakayama, Shin-ichiro Shoda, Tetsutaro Hattori, Nobuyuki Uozumi, Mitsuo Umetsu, Hitoshi Kasai</p> <p>Lecture: This lecture will deal with various aspects of biomolecular engineering from basic knowledge to advanced subjects. Focus will be placed on several topics of biosensing technologies, biomolecular recognition, biochemistry of flavonoids, chemical biology of carbohydrates, bioenergetics, protein engineering of immunological receptors.</p>
<p>Name of Department: Department of Civil and Environmental Engineering  Name of Lecture: <u>Advanced Environmental Hydraulics and Water Quality Engineering</u>  Schedule: July and/or August, 2019(Every other year)  Instructors: Professors Hitoshi Tanaka, Fumihiko Imamura, Osamu Nishimura, So Kazama, Shunichi Koshimura, Associate Professors Makoto Umeda, Keiko Udo, Kengo Kubota, Suppasri Anawat, Takashi Sakamaki, Mas Erick</p> <p>Lecture: This lecture will deal with various aspects of environmental hydraulics and water quality engineering from basic knowledge to advanced subjects. Focus will be placed on several topics such as remote-sensing technique, estuarine hydrodynamics, environmental protection engineering and water quality management.</p>
<p>Name of Department: Department of Quantum Science and Energy Engineering  Name of Lecture: <u>Medical Molecular Engineering</u>  Schedule: February and/or March, 2018  Instructors: Professor Atsuki Terakawa</p> <p>Lecture:</p> <ol style="list-style-type: none"> <li>1. Charged-particle cancer therapy and its related physics and technology</li> <li>2. High-resolution PET technology</li> <li>3. Molecular imaging technology</li> <li>4. Micro-beam technology and its biomedical applications</li> </ol>

## Group B: Green Innovation

Name of Department: Department of Applied Physics

Name of Lecture: Quantum Material Physics

Schedule: to be determined

Instructors: Professors Yasuo Ando, Takumi Fujiwara, Yuzuru Miyazaki, Takashi Matsuoka

Lecture: This course is composed of four topics: Ceramics conductors; Materials science and device applications of wide-gap semiconductors; Spintronics; Fabrication and nonlinear optical study of crystallized glass with laser-induced nanostructures.

The first part of the course focuses on exotic features of synthesized electrical conducting ceramics i.e. the superconductivity, significant thermoelectric power, colossal magnetoresistance and photoconductivity. Their common and characteristic crystal structures will also be discussed in terms of point groups and space groups.

The next part of the course aims to give a comprehensive review of materials and devices of narrow- and wide-gap semiconductors, ranging from basic materials science to advanced optical device applications. The materials to be discussed will include conventional III-V and group III nitride semiconductors.

The third part of this course gives a review of recent development of spintronics. Various kinds of magnetoresistance effects such as giant magnetoresistance (GMR) effect and tunnel magnetoresistance (TMR) effect will be explained in detail. Applications of such effects to electronic devices will also be presented.

The final part of the course describes the controlling light with nonlinear optical materials and photonic glasses. Fabrication of nano-crystallized glass with laser-induced ordered structures and their photonic applications such as the novel electro-optic fiber-type devices and localization/propagation of light in photonic glasses will be introduced.

Name of Department: Department of Chemical Engineering

Name of Lecture: Advanced Process Analysis and Modeling

Schedule: July and/or August, 2020

Instructors: Professors Hideyuki Aoki, Daisuke Nagao, Takao Tsukada, Hiroshi Inomata, Masato Kakihana, Chiaki Yokoyama, Tadafumi Ajiri

Lecture: This course is designed to provide Ph.D. graduate students with guidance and experience in analysis and modeling of chemical processes such as energy processes, separation and/or reaction processes and large-scale chemical process systems.

Name of Department: Department of Architectural & Building Science

Name of Lecture: CFD modeling for building environment design

Schedule: April to July, 2018

Instructors: Professor Akashi Mochida

Lecture: Turbulent diffusion strongly influences the wind environment in urban area, wind loading on structure, thermal environment and air quality in and around buildings. An introduction is given to CFD simulations of airflow related phenomena in and around buildings using various turbulence models, namely standard and revised k-e models, ASM, DSM and LES. Canopy flow modeling for reproducing aerodynamic effects of flow obstacles whose sizes are smaller than computational grid cell is also introduced. Emphasizes are placed on the performance of these models and the essentials of modeling techniques when they are applied to complex flow-fields related to built environment. Furthermore, the way how the turbulent flow simulations can be utilized for environmental design is also provided.

Name of Department: Department of Management Science and Technology

Name of Lecture: Advanced Energy Systems and Society

Schedule : October, 2017 to February, 2018

Instructors: Professor Toshihiko Nakata

Lecture: Efficient energy utilization is an essential solution to mitigate global warming. The various aspects of energy system are defined and discussed. In particular, social and economic dimension of energy policy are stressed. The class will give energy efficiency, renewables, distributed energy systems, engineering economics, environmental taxes, environmental management etc. Active participation in class will be appreciated.

Name of Department: Department of Frontier Sciences for Advanced Environment, Graduate School of Environmental Studies

Name of Lecture: Advanced Eco-engineering Systems

Schedule: August, 2018

Instructors: Professors SMITH Richard Lee Jr, Hideaki Matsubara, Associate Professors Hitoshi Shiku, Koichi Suto

Lecture: This lecture includes subjects concerning on chemical and physical properties of materials for environmental industry, chemical engineering process toward environmental load reduction, basics and applications of supercritical fluid. Topics will be selected from the backgrounds including material science, physical chemistry, and chemical engineering. Students will learn expert knowledge of individual topics and find out problems to be solved.

Name of Department: Department of Frontier Sciences for Advanced Environment, Graduate School of Environmental Studies

Name of Lecture: Advanced surface and subsurface measurements for environmental science

Schedule: August, 2019

Instructors: Professors Motoyuki Sato

Lecture: In this course, applications of electromagnetic wave to environmental monitoring will be discussed. We will study Ground Penetrating Radar (GPR) technology and Synthetic Aperture Radar (SAR) technology and advanced electromagnetic sciences.

Name of Department: Department of Environmental Studies for Advanced Society, Graduate School of Environmental Studies

Name of Lecture: Advanced Studies on International Resource Strategy

Schedule: August, 2020

Instructors: Professors Noriyoshi Tsuchiya, Takeshi Komai, Toshinobu Machida

Lecture: Formation mechanisms and evolution of the Earth system, particularly atmosphere and geosphere, can be studied. Catastrophe and future estimation, environmental risk, health risk and risk management can be studied in this class.

Name of Department: Department of Applied Chemistry

Name of Lecture: Advanced Course in Atoms & Molecules Control Engineering

Schedule: July and/or August, 2019

Instructors: Professors Yuji Matsumoto, Keiichi Tomishige, Hitoshi Shiku, Hirotsugu Takizawa, Keisuke Asai, Takashi Kyotani, Atsushi Muramatsu, Tomoyuki Akutagawa, Masaru Nakagawa, Masaya Mitsuishi, Hiroshi Jinnai

Lecture: This lecture will deal with various aspects of energy engineering from basic knowledge to advanced subjects. Focus will be placed on several topics of manipulation of atoms and molecules, recycling chemistry, hydrocarbon chemistry, electrochemical science and technology, inorganic reactions, reactions of solids, organic resources chemistry, physical recycling process engineering, chemical recycling process engineering, colloid chemistry, aqueous processing and environment protection technology.

Name of Department: Department of Metallurgy

Name of Lecture: Advanced Course on Materials Physical Chemistry

Schedule: July and/or August, 2019

Instructors: Professors Hongmin Zhu, Yoshitaka Kasukabe, Shigeru Suzuki

Lecture: This lecture deals with fundamental and applied physical chemistry based on the statistical mechanics, chemical thermodynamics, thermophysics, electrochemistry, X-ray scattering, high energy beam and surface treatment, and is focused on various materials such as molten metals and salts, high purity metals, semiconductors, metallic compounds, nano-materials, biomaterials, non-equilibrium materials, surface and interfaces.

Name of Department: Department of Materials Science

Name of Lecture: Advanced Topics on Highly Sophisticated Materials

Schedule: July and/or August, 2019

Instructors: Professors Junsaku Nitta, Junichi Koike, Kyosuke Yoshimi, Yutaka Oyama, Koki Takanashi, Kazumasa Sugiyama, Toyohiko Konno, Shunichi Sato, Hiroshi Ohtani

Lecture: This lecture will deal with various topics on highly sophisticated materials in the advanced fields of materials science, and will mainly be focused on several topics such as electronic and magnetic materials, optic materials, functional materials, superlattices, surface characterization, microstructural control.

Name of Department: Department of Materials Science

Name of lecture: Advanced Topics on High Performance Materials

Schedule: July and/or August, 2019

Instructors: Professors Izumi Muto, Satoshi Sugimoto, Hitoshi Takamura, Atsushi Momose,

Lecture: This lecture will deal with various aspects of high performance functional materials from basic knowledge to advanced subjects. They includes topics on structural materials, materials for information technologies (electronics, opto-electronics and spin-electronics), and materials for energy technologies. They contain metals, semiconductors and ceramics.

## Group C: Safety and Security

Name of Department: Department of Aerospace Engineering

Name of Lecture: Shock Wave in Complex Media and their Interdisciplinary Applications

Schedule: July and/or August, 2018

Instructors: Associate Professor Mingyu Sun

Lecture: Shock waves in nature are of a wide range of length scales, such as gigantic shock waves in supernova explosions, and micro-shock waves induced by a tiny collapsing bubble. Mathematically, a discontinuous shock wave appears as a natural solution to the non-linear hyperbolic partial differential equations or the nonlinear wave equations, such as the compressible Euler equations in aerodynamics. Some behaviors of human society are analogous to shock waves, such as the propagation of rumor, panic motion etc. Encouraged by the remarkable development of computing and experimental techniques, the shock wave research today can extend its capabilities to various interdisciplinary topics that were hardly discussed before. Research results regarding various shock wave motions in complex media and then their interdisciplinary applications will be presented in this lecture. Examples will include geophysical applications such as volcanology, the effect of underwater shock waves created in asteroid impacts on the earth, mass extinction, physics of hypervelocity impacts, in addition to its traditional applications in aerodynamics.

Name of Department: Department of Civil and Environmental Engineering

Name of Lecture: Advanced Civil Engineering Structures

Schedule: July and/or August, 2018 (Every other year)

Instructors: Professors Kiyohiro Ikeda, Motoki Kazama, Takashi Kyoya, Makoto Hisada, Kenjiro Terada, Shigeki Unjoh, Associate Professors Yuki Yamakawa, Isao Saiki, Hiroshi Minagawa, Hideki Naito, Tadashi Kawai, Junji Kato, Shuji Moriguchi

Lecture: This lecture will deal with various aspects of civil engineering. Focus will be placed on topics of mathematical system design, civil engineering structures, regional system engineering, and infrastructural materials.

Name of department : Department of Mechanical Systems Engineering, Department of Finemechanics

Name of Lecture: Advanced Damage Tolerance and Design

Schedule: July and/or August, 2018

Instructors: Professors Masumi Saka and Hitoshi Soyama

Lecture: Lecture will deal with various aspects of design concepts and estimation of damage tolerance.

Furthermore, to avoid various accident for aircraft, electric power plant and nuclear engineering, new concepts on the prediction of fracture life and the estimation of damage accumulation are discussed from the view points of advanced adaptive engineering.

The contents of the lecture are as follows.

1. What is the system design?
2. Fundamental concept of fracture mechanics
3. The process of accident occurrence
4. Theory of fatigue crack growth, and the law of crack growth life
5. Theory of fatigue threshold
6. Evolution of design strategies for structural integrity
7. Damage tolerance concept and its application to aircraft industry
8. Three distinct elements in damage tolerance design (based on Boeing's concept);
  - Residual strength (allowable defect size)
  - Sub-critical crack growth
  - Damage detection (inspection program)
9. Introduction — Necessity of new approaches
10. Lessons from case studies
11. Foundation of design and evaluation of human-machine interface
12. Organizational accidents and process-oriented safety measures
13. Latent risk of computer-based systems
14. Self organization of biological tissue materials
15. Summary

Name of Department: Department of Communication Engineering, Department of Electronic Engineering

Name of Lecture: Advanced High-Speed Communication Engineering

Schedule April to September, 2018

Instructors: Professors Hideo Ohno, Yasuo Cho, Masataka Nakazawa, Taiichi Otsuji, et al

Lecture: This series of lectures provide with various topics in the field of high-speed and high frequency communication engineering. Each lecture consists of a review and discussion in the areas of microwave, infrared, submillimeter wave, terahertz, acoustoelectronic, and quantum electronic engineering.

<p>Name of Department: Department of Metallurgy  Name of Lecture: <u>Metallurgical Process Engineering</u>  Schedule: July and/or August, 2018  Instructors: Professors Tetsuya Nagasaka, Koichi Anzai, Ryosuke Kainuma, Shinya Kitamura, Tadashi Furuhashi</p> <p>Lecture: This lecture will deal with the process of material production. Focus will be placed on thermodynamics, physico-chemical properties, interfacial phenomena, solidification, material processing metallurgical processes, and the environmental problems related to the current processes.</p>
<p>Name of Department: Department of Quantum Science and Energy Engineering  Name of Lecture: <u>Advanced Quantum Science and Energy Engineering</u>  “Biotechnology and Advanced nuclear techniques, fundamentals and applications”  Schedule: August and/or September, 2019  Instructors: Professors Tomohiko Iwasaki</p> <p>Lecture: This lecture will deal with the following topics.</p> <ol style="list-style-type: none"> <li>1. The engineering and physics foundation, and innovative technologies of nuclear energy systems, safety systems, and recycling systems.</li> <li>2. The engineering and physics foundation of advanced nuclear reactors, such as nuclear fusion and ADS.</li> <li>3. The science and innovative technology for high loading energy.</li> <li>4. Applied particle-beam technology.</li> </ol>
<p>Name of Department: Department of Electronic Engineering  Name of Lecture: <u>Advanced Electronic Device Engineering</u>  Schedule: July and/or August, 2017  Instructors: Professors Hiroshi. Yasaka, Taiichi.Otsuji, Shigeo.Sato, Associate Professors Shunsuke.Fukami</p> <p>Lecture: Various lectures on the advanced electronic devices for memories, data storage, communication, photo-electronics, semiconductor devices, etc. will be delivered. They include relevant fundamental theories and knowledge of material engineering, spintronics, magnetism, silicon technologies, photonics, and quantum electronic engineering.</p>
<p>Name of Department: Department of Materials Processing  Name of Lecture: <u>Advanced Materials Processing</u>  Schedule July and/or August, 2019  Instructors: Professors Tsuyoshi Mihara, Akira Kawasaki, Takayuki Narushima, An Pang Tsai, Daisuke Shindo, Hisanori Yamane, Takashi Goto, Akihiko Chiba, Hiroshi Masumoto, Akira Yoshikawa,</p> <p>Lecture: The lecture deals with a wide range of materials processing from basic knowledge to advanced subjects. It is intensively focused on several topics of functions of material systems, applied elasticity and plasticity, numerical analysis of materials processing, structural characterization of materials, powder process technology, materials engineering in processing, evaluation of material systems, liquid state processing, and joining science and technology.</p>
<p>Name of Department: Department of Architectural &amp; Building Science  Name of Lecture: <u>Geological Environment and Earthquake Disaster</u>  Schedule: July and/or August, 2019  Instructors: Professors Masato Motosaka, Associate Professors Susumu Ohno</p> <p>Lecture: It is clear through past disastrous earthquakes that the earthquake damage is quite different due to the geological conditions. The earthquake observation explains this truth. It is important to take into account the difference of ground motion due to soil conditions in a seismic design of urban structures and in urban disaster prevention planning. In this course, the following topics are addressed.</p> <ol style="list-style-type: none"> <li>1) Recent damage earthquakes and ground motion characteristics</li> <li>2) Seismic wave propagation from source to building -phenomena and theory-</li> <li>3) Geological structure and ground motion -ground motion amplification characteristics-</li> <li>4) Earthquake resistant design/seismic diagnosis and soil conditions</li> <li>5) Earthquake damage prediction in urban area -natural and social information-</li> <li>6) Earthquake disaster prevention planning</li> </ol>