

**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

（留学生特別コース）



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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 and Design	11. Chemical Engineering	19. Computer and
2. Nanomechanics	12. Biomolecular Engineering	Mathematical Sciences
3. Aerospace Engineering	13. Metallurgy	20. System Information Sciences
4. Quantum Science and	14. Materials Science	21. Human-Social Information
Energy Engineering	15. Materials Processing	Sciences
5. Bioengineering and Robotics	16. Civil and	22. Applied Information Sciences
6. Electrical Engineering	Environmental Engineering	23. Environmental Studies
7. Communication Engineering	17. Architecture and	24. Biomedical Engineering
8. Electronic Engineering	Building Science	
9. Applied Physics	18. Management Science and	
10. Applied Chemistry	Technology	

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。

*Period I corresponds to the period from October 2015 to September 2016, Period II and III are 2016 to 2017 and 2017 to 2018, respectively.*

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

## **Group A: Life Science**

### **Period I**

- (6)(24) (未定) , October and/or November, 2016  
(19) Advanced Topics in Neuroscience (神経科学の進歩／情報) , 1st Semester, 2017

### **Period II**

- (5) Advanced Bio-Mechanics (バイオメカニクス特論／ロボ) , 2nd Semester, 2017  
(12) Advanced Biomolecular Engineering (応用生命化学特論／パ工) , July and/or August, 2015  
(16) Advanced Environmental Hydraulics and Water Quality Engineering (水環境学特論／土木) ,  
July and/or August, 2015(Every other year)

### **Period III**

- (4) Medical Molecular Engineering (分子医工学／量子) , August and/or September, 2016

## **Group B: Green Innovation**

### **Period I**

- (9) Quantum Material Physics (量子材料物理／応物) , February, 2017  
(11) Advanced Process Analysis and Modeling (プロセス解析工学特論／化工) , July and/or August, 2017  
(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, 2017  
(23) Advanced Environmental Resources Chemistry (環境資源・材料化学特論／環境) , August, 2017

### **Period II**

- (18) Advanced Energy Systems and Society (エネルギー社会システム特論／技術) ,  
October to December, 2017  
(23) Advanced Environmental Studies on Geothermal Energy (国際エネルギー環境学特論／環境) , August, 2015

### **Period III**

- (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, 2016  
(13) Advanced Course on Materials Physical Chemistry (材料理化学特論／金フ) , July and/or August, 2016  
(14) Advanced Topics on Highly Sophisticated Materials (物性制御学特論／知材) , July and/or August, 2016  
(14) Advanced Topics on High Performance Materials (高機能材料科学特論／知材) , July and/or August, 2016

## **Group C: Safety and Security**

### **Period I**

- (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, 2017  
(16) Advanced Civil Engineering Structures (社会基盤構造学特論／土木) ,  
July and/or August, 2015(Every other year)  
(18) Advanced Topics on Science & Technology Policy (実践技術政策特論／技術) , October 2016 to February, 2017

### **Period II**

- (1)(2) Advanced Damage Tolerance and Design (損傷計測学特論／機シ, ナノ) , July and/or August, 2015  
(7)(8) Advanced High-Speed Communication Engineering (先端超高速情報工学／通信, 電子) ,  
April to September, 2015  
(13) Metallurgical Process Engineering (金属プロセス工学特論／金フ) , July and/or August, 2015

### **Period III**

- (4) Advanced Quantum Science and Energy Engineering (量子エネルギー工学特論／量子) ,  
August and/or September, 2016  
(8) Advanced Electronic Device Engineering (電子デバイス工学特論／電子) , July and/or August, 2016  
(15) Advanced Materials Processing (材料システム工学特論／材シ) , July and/or August, 2016  
(17) Geological Environment and Earthquake Disaster (地盤環境と地震災害／建築) , July and/or August, 2016

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



# International Doctoral Program in Engineering, Information Sciences, Environmental Studies and Biomedical Engineering Syllabus for 2015-2017 COURSE GROUPS

*Period I corresponds to the period from October 2015 to September 2016,  
Period II and III are 2016 to 2017 and 2017 to 2018, respectively.*

## Group A: Life Science

### Period I

<p>Name of Department: Department of Electrical Engineering and Department of Biomedical Engineering</p> <p>Name of Lecture : <u>Advanced Bioelectromagnetics</u></p> <p>Schedule: October and/or November, 2016</p> <p>Instructors: Professor Hidetoshi Matsuki</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</p> <p>Name of lecture: <u>Advanced Topics in Neuroscience</u></p> <p>Schedule: 1st Semester, 2017</p> <p>Instructors: Prof. Keiichi Itoi, Assis. Prof. Katsuya Uchida, Assis. Prof. Toshimitsu Fuse</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>

### Period II

<p>Name of Department: Department of Bioengineering and Robotics</p> <p>Name of Lecture: <u>Advanced Bio-Mechanics</u></p> <p>Schedule: 2nd Semester, 2017</p> <p>Instructors: Professors Yoichi Haga</p> <p>Lecture: Undecided</p>
<p>Name of Department: Department of Biomolecular Engineering</p> <p>Name of Lecture: <u>Advanced Biomolecular Engineering</u></p> <p>Schedule: July and/or August, 2015</p> <p>Instructors: Professors Toru Nakayama, Shin-ichiro Shoda, Tetsutaro Hattori, Nobuyuki Uozumi, Masatsugu Shimomura</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</p> <p>Name of Lecture: <u>Advanced Environmental Hydraulics and Water Quality Engineering</u></p> <p>Schedule: July and/or August, 2015(Every other year)</p> <p>Instructors: Professors Hitoshi Tanaka, Hideki Harada, Akira Mano, Fumihiko Imamura, Osamu Nishimura, So Kazama, Shunichi Koshimura, Associate Professors Makoto Umeda, Koki Goto, Keiko Udo</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>

### Period III

Name of Department: Department of Quantum Science and Energy Engineering

Name of Lecture: Medical Molecular Engineering

Schedule: August and/or September, 2016

Instructors: Professor Hiroshi Ohtsu

Lecture:

1. Introduction: Overview of technology used in the medical science
2. Cell and cellular chemistry
3. The flow of genetic information. (The organization of cellular genomes, Replication, maintenance, and rearrangements of genomic DNA, RNA synthesis and processing, Protein synthesis, processing and regulation)
4. Cell structure and function
5. Cell regulation

### Group B: Green Innovation

#### Period I

Name of Department: Department of Applied Physics

Name of Lecture: Quantum Material Physics

Schedule: February 2017

Instructors: Professors Yasuo Ando, Takumi Fujiwara, 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, 2017

Instructors: Professors Hideyuki Aoki, Toshikuni Yonemoto, Mikio Konno, 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, 2017

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 models 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 flowfields 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 Environmental Studies, Graduate School of Environmental Studies

Name of Lecture: Advanced Environmental Resources Chemistry

Schedule: August, 2017

Instructors: Professors Tsugio Sato, Koji Ioku, Toshiaki Yoshioka, Tadashi Honma, Nobuhiko Iki, Toshikazu Shiratori

Lecture: This lecture deals with various aspects of environmental chemistry and engineering. We will select topics on, resources circulation and recycling, renewable energy, analytical systems for environmental load materials, and material design harmonized with environment.

## Period II

Name of Department: Department of Management Science and Technology

Name of Lecture: Advanced Energy Systems and Society

Schedule : October to December, 2017

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 Environmental Studies, Graduate School of Environmental Studies

Name of Lecture: Advanced Environmental Studies on Geothermal Energy

Schedule: August, 2015

Instructors: Professors Hiroshi Takahashi, Tatsuya Kawada, Toshiyuki Hashida, Takatoshi Ito

This lecture deals with next-generation energy system such as geothermal energy and fuel cell system. Furthermore, this lecture deals with advanced technology of underground storage of CO<sub>2</sub>, environmental problems for several construction wastes, and crustal system for geological disposal of radiation wastes.

### Period III

Name of Department: Department of Applied Chemistry

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

Schedule: July and/or August, 2016

Instructors: Professors Yuji Matsumoto, Tomishige Keiichi, Hirotsugu Takizawa, Keisuke Asai, Shuichi Oi, Takashi Kyotani, Atsushi Muramatsu, Tomoyuki Akutagawa, Masaru Nakagawa, Kazue Kurihara

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, 2016

Instructors: Professors Yoshitaka Kasukabe, Shun-ichiro Tanaka, 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, 2016

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

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, 2016

Instructors: Professors Nobuyoshi Hara, Satoshi Sugimoto, Akihiro Makino, Mitsuo Niinomi, Mingwei Chen

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

### Period I

Name of Department: Department of Aerospace Engineering

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

Schedule: July and/or August, 2017

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, 2017 (Every other year)

Instructors: Professors Kiyohiro Ikeda, Motoki Kazama, Tetsuo Iwakuma, Motoyuki Suzuki, Takashi Kyoya, Makoto Hisada, Kenjiro Terada, Associate Professors Yuki Yamakawa, Isao Saiki, Hiroshi Minagawa, Hideki Naito, Tadashi Kawai

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 Management Science and Technology

Name of Lecture: Advanced Topics on Science, Technology and Innovation Policy

Schedule: October 2016 to February 2017

Instructors: Professor Yuko Harayama

Lecture: This lecture will deal with various aspects of science, technology and innovation policy, from basic innovation models to some specific national and global STI issues. Focus will be placed on several topics, such as innovation and economic growth, university-industry relationships, social and global challenges, and policy evaluation.



## Period II

Name of department : Department of Mechanical Systems and Design, Department of Nanomechanics

Name of Lecture: Advanced Damage Tolerance and Design

Schedule: July and/or August, 2015

Instructors: Professors Toshimitsu Yokobori, 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 is 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, 2015

Instructors: Professors Fumiyuki Adachi, 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.

Name of Department: Department of Metallurgy

Name of Lecture: Metallurgical Process Engineering

Schedule: July and/or August, 2015

Instructors: Professors Tetsuya Nagasaka, Koichi Anzai, Ryosuke Kainuma, Fumio Fujita, Shinya Kitamura, Tadashi Furuhashi

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.

### Period III

Name of Department: Department of Quantum Science and Energy Engineering

Name of Lecture: Advanced Quantum Science and Energy Engineering

“Biotechnology and Advanced nuclear techniques, fundamentals and applications”

Schedule: August and/or September, 2016

Instructors: Professors

Lecture:

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.

Name of Department: Department of Electronic Engineering

Name of Lecture: Advanced Electronic Device Engineering

Schedule: July and/or August, 2016

Instructors: Professors Michio Niwano, Yasuo Cho, Hideo Ohno

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.

Name of Department: Department of Materials Processing

Name of Lecture: Advanced Materials Processing

Schedule July and/or August, 2016

Instructors: Professors Hiroyuki Kokawa, Yasuhide Shindo, Akira Kawasaki, Kazushi Yamanaka, Makoto Suzuki, Takayuki Narushima, An Pang Tsai, Daisuke Shindo, Hisanori Yamane, Takashi Goto, Akihiko Chiba, Tetsuo Taniuchi, Hiroshi Masumoto, Akira Yoshikawa

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.

Name of Department: Department of Architectural & Building Science

Name of Lecture: Geological Environment and Earthquake Disaster

Schedule: July and/or August, 2016

Instructors: Professors Masato Motosaka, Associate Professors Susumu Ohno

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.

- 1) Recent damage earthquakes and ground motion characteristics
- 2) Seismic wave propagation from source to building -phenomena and theory-
- 3) Geological structure and ground motion -ground motion amplification characteristics-
- 4) Earthquake resistant design/seismic diagnosis and soil conditions
- 5) Earthquake damage prediction in urban area -natural and social information-
- 6) Earthquake disaster prevention planning

