



東北大学

Tohoku University

文部科学省 博士課程教育リーディングプログラム 複合領域型 (物質)

Program for Leading Graduate Schools, MEXT
Multidisciplinary Field of Materials

マルチディメンジョン物質工学リーダー養成プログラム

Interdepartmental Doctoral Degree Program
for Multi-dimensional Materials Science Leaders
(MD program)

履修要項

Course Guideline

令和2年度

Academic Year 2020

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1. Educational and Diploma granting policies of the Tohoku University's Program for Leading Graduate Schools

Tohoku University Mission Statement

Since it was founded, Tohoku University has been committed to the “Research First” principle and “Open Door” policy, and produces world-class research and education. The university contributes to peace and equity for human society by conducting research that is useful in solving problems that society faces, and educating human resources to be capable of leadership.

From the application guidelines for the Program for Leading Graduate Schools (2013)

The “Program for Leading Graduate Schools” supports reform in Japanese higher education to promote the formation of a graduate school that is suitable for being the highest level of educational institution. Its aim is to shape graduates into creative, visionary global leaders with the capacity to play active roles in industry, government, and academic institutions. To do so, it assembles top-level faculty and students from inside and outside of Japan, and involves external institutions spanning industry, academia, and government in order to deliver quality-assured, globally applicable programs that transcend the traditional boundaries between disciplines and follow a consistent course from the Master’s program through the Doctor’s program.

(1) Goals for the development of human resources in the Program for Leading Graduate Schools

The goal of the program is to cultivate leaders with the capacity to play active roles globally in industry, government, and academic institutions, with (1) the ability to take bold action globally while collaborating with others, based on a steadfast set of values, (2) the ability to take initiative in seeking out problems, constructing hypotheses, and using knowledge at hand to tackle the problems, and (3) the vision to grasp the true nature of things based on wide-ranging expertise and deep global perspective.

(2) Admission policies for the Program for Leading Graduate Schools

Desired participants are those who empathize with the goals of the Program for Leading Graduate schools at Tohoku University and have the fundamental abilities and educational background to achieve those goals, in addition to having ethical standards, and strong motivation to participate in the program.

Details of admission policies are determined by the corresponding program.

(3) Curriculum Policies at the Program for Leading Graduate Schools

The program formulates and implements world-class curriculum that uses access to participating industry, academic, and governmental institutions, and developmental self-instruction through conversations with multiple instructors and leaders from inside and outside of Japan to foster the abilities necessary to follow through on research plans, present explanations to society, and look out over a wide variety of disciplines to organize a research team, lead global efforts to pioneer new fields of research, and find creative solutions to problems.

The curriculum policy is to formulate and implement curriculum that produces comprehensive understanding of disciplines through research guidance by multiple instructors, while students also master the wide-range of knowledge related to the program through diverse quality-assured professional education during the term of study leading up to the doctoral dissertation defense. The policy also aims to lead students toward acquiring communication skills, planning skills, the ability to mobilize research and development, and the skills to discover problems on their own, through practical education involving collaboration with industry, government, and academic institutions, among other activities.

Details of curriculum policies are determined by the corresponding program.

(4) Diploma Policies at the Program for Leading Graduate Schools

The standards for completion of the Master's program are whether the student has gained deep and wide-ranging knowledge that transcends the boundaries of separate disciplines, and has acquired the superior knowledge, abilities, and global communication skills to be a Materials Science leader that must be able to see the future from a broad perspective. The requirements to be awarded a degree for completion of the Doctoral program are that students must be in school for the duration of the program, and that they undergo research training in accordance with the principles and goals of the program for developing Materials Science leaders of the future, in addition to passing a test and a specialized dissertation examination at the research laboratory to which they belong within the predetermined number of years, and also passing the QE2 (Qualifying Examination 2 for doctoral course students) conducted by the MD program.

MD program is a five-year integrated Master's and Doctoral program, and it is ultimately most important to complete all scholastic achievement goals A) through H) indicated in section 4, item (1). That is to say, the criteria for completion of the program are whether the student has acquired the scholastic acumen that forms the basis for being able to work as a future Materials Science leader in a wide range of global endeavors, and whether they also have the skills necessary to act creatively as an independent researcher and technician that engages in work involving advanced specialized expertise. Another important point to consider for completion of graduate studies is whether the student shows high levels of ethics and strong sense of responsibility in conducting

research and other such activities, and whether they are inclined towards the coexistence of human society and nature.

2. The Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders (MD program)

The Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders (MD program) has brought together the best of the Materials Science wisdom that Tohoku University proudly possesses, to cultivate Materials Science leaders with strong foundations and broad perspectives to dynamically deal with issues in the materials field. The program aims to develop Materials Science leaders who can envision multi-dimensional materials design concepts, and have the extensive fundamental knowledge and wide-ranging research experience to help bring those concepts to life. In the context of this program, “multi-dimensional” means using multiple perspectives and dimensions to gain a broader, more elevated view on the following attributes:

- Functions (light generating, catalytic, conduction, magnetism, etc.)
- Characteristics (intensity, efficiency, threshold limit value, etc.)
- Processes (raw materials, production processes, device integration, etc.)
- Environmental compatibility (low carbon, high recyclability, etc.)
- Economic aspect (cost, balance between supply and demand, etc.)
- Safety, evaluations, etc.

Figure 1

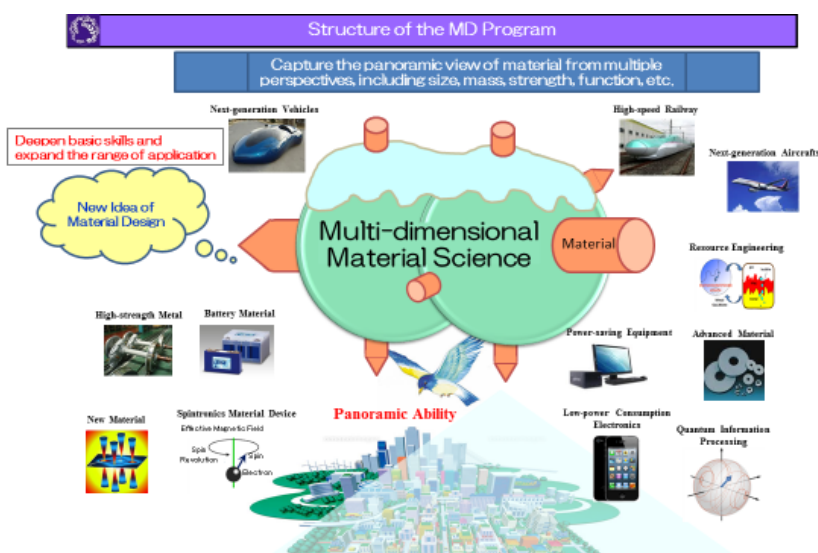


Figure 1 shows the layout of the comprehensive education designed to cultivate human resources with these abilities. The components include two cores in physical sciences and engineering which form the basis and application. “Materials Science” is inserted horizontally connecting the basic foundation of mathematics, chemistry, and physics, while humanities and social sciences such as pharmaceuticals, environmental science, economics, and philosophy are also aligned as educational components.

3. Curriculum for the MD program

(1) Goals for Educational Achievement

The educational achievement goals for this program are as follows.

- A) To attain a high level of basic fundamental knowledge in Materials Science.
- B) To possess broad vision and thinking skills that can be applied to other fields, while also gaining sophisticated capabilities as a specialist.
- C) To learn the newest scientific and technical information and methods for experiments and research pertaining to multiple specific fields in Materials Science.
- D) To understand information about the forms in which society applies production processes for materials, and gain the skills to be able to utilize them.
- E) To search for appropriate research topics independently, and acquire the skills to implement research plans.
- F) To acquire the communication skills to be able to sufficiently assert an opinion, engage in debates, and exchange views in a global setting, as well as the ability to widely transmit the findings from research.
- G) To acquire basic knowledge of ethics, management, and operational methods for organizations, and also attain the ability to proactively spur collaborations with other organizations.
- H) To apply the skills described above, respond to requests from society, and acquire practical leadership skills.

(2) Basic Curriculum Structure

Figure 2 The Basic Curriculum Structure designed for the Educational Achievement Goals

First and second year Equivalent to the Master's degree program		Typical Subjects	Minimum credits required	Acquire fundamental knowledge	Broaden Expertise	Deepen Expertise	Acquire Adequate under- standing	Acquire skills to search for research topics	Develop communi- cation skills	Acquire management skills	Cultivate leadership skills
Group 1	Basic Subjects for MD Material Science and Engineering	Introduction to MD Material Science and Engineering, Ethics for Scientist, MD Fundamental Material Mathematics, etc.	6	●	○						
Group 2	Basic/General subjects	Those Approved by the department you belong.	10	○	●						
Group 3	Expansion Subjects for MD Material Science and Engineering	Practical Material Science and Engineering I-X	10		○		●	○			
Group 4	Applied Subjects for MD Material Science and Engineering	MD Training for Global Communication Skill I, II, Lecture for Safety Management and Control of Organization, Lecture for Leadership Education I	4						●	●	○
Group 5	Internships I	Internship in MD Program, etc.	2		●	●		○	○		
Group 6	Master Course Seminar		6	○	●	●	○	○	○	○	●
Total credits required in master's course			38								
Third, fourth and fifth year Equivalent to the Doctoral Course		Typical Subjects	Required Credits								
Group 7	Expansion Subjects for MD Materials Science and Engineering	Special Lecture for Practical Science and Engineering I-IV	4			○				●	
Group 8	Practical Application Subjects for MD Materials Science and Engineering	Seminar and Practice for Practical Science and Engineering, etc.	2					○			●
Group 9	Internships II	Internship in Industries, etc.	6				●			○	
Group 10	Overviews		2			●		●			
Group 11	Doctoral Course Seminar		8	○	○	●	○	●	●	○	●
Total credits required in doctoral course			22								

● Top priority elements
○ Key elements

Figure 2 illustrates the basic curriculum structure designed for the educational achievement goals of this program.

This curriculum for this program consists of six course groups (program equivalent) in the Master's program, and five course groups in the Doctoral program. Completion of studies in the Master's program requires a minimum total of 38 credits, and the Doctoral program requires a minimum of 22 credits.

The educational achievement goals that specifically indicate the ideal personnel for this program are clarified in A) through H) as previously mentioned. The curriculum aligns course groups to facilitate the achievement of each educational achievement goal, and is designed so that all students completing studies will have achieved every one of the educational achievement goals.

The Center for Education and Research on Multi-dimensional Materials Science courteously provides each individual student with updates and guidance pertaining to their study progress, in accordance with the relationship between educational achievement goals and course groups as indicated in Figure 2.

(3) Course Groups and the Credits Requirements for the Completion of Studies

First and second year (equivalent to the Master's degree program)

Group 1: Basic Subjects for MD Materials Science and Engineering

*Required credits: 6 or more (2 out of 6 are compulsory)

This group consists of fundamental courses for thorough basic education that transcends barriers between traditional disciplines, including courses such as “Introduction to MD Material Science and Engineering” (1credit, compulsory), “Ethics for Scientists” (1credit, compulsory), “MD Fundamental Material Physics” (2credits, elective), “MD Fundamental Material Chemistry” (2credits, elective), “MD Fundamental Material Mathematics” (2credits, elective), etc.

Group 2: Major Basic Subjects and Major General Subjects

* Required credits: 10 or more

Courses for the core area of specialization that the student belongs to. Fundamentally, students must thoroughly study their respective areas of specialization, but based on their interests pertaining to the program, the courses that they select shall be decided through detailed consultation with an academic adviser.

Group 3: Expansion Subjects for MD Material Science and Engineering

* Required credits: 10 or more

The course group made up of “Practical Materials Science and Engineering I through X” (2credits, elective). Based on fundamental principles and following the perspective of the lifecycles of materials, learn about what kinds of processes and device integration methods raw materials are put through to be made ready for practical use, and what types of equipment and systems they are combined with.

Group 4: Applied Subjects for MD Material Science and Engineering

* Required credits: 4, compulsory

Important courses for developing international leadership, including “MD Training for Global Communication Skill I” and “II”. Additionally, company representatives who participate in industry-university collaborative platforms teach “Lecture for Safety Management and Control of Organization I ”and “Lecture for Leadership Education I ”as guest speakers. These courses are uniquely planned in the program to expose students to the management and operational expertise required of someone who leads a department of a company.

Group 5: Internships I

* Required credits: 2 or more (during the Master's program)

This course group consists of “Internship in Industries”, “Internship in Overseas”, and “Internship in MD program”.

The basis of “Internship in Industries” is on-site training at the production site of the company that the student is matched with, as it is considered important for the student to experience a production site related to their doctoral dissertation research.

For overseas internships, each area of specialization makes effective use of our ever-growing overseas networks. For example, the three areas of specialization in the School of Engineering Materials Science Department have close associations with the following universities: University of Science and Technology Beijing and Tsinghua University in China, Pohang University of Science and

Technology in South Korea, Royal Institute of Technology in Sweden, and University of Washington and Yale University in the United States. There are no difficulties whatsoever in sending students to study abroad at these universities.

For “Internship in MD program”, students stay at laboratories outside of their areas of specialization for at least 3 months, and pursue a research topic other than the topic of their doctoral dissertation research. During the five-year course of study, students must complete a “Internship in Industries”, a “Internship in Overseas”, and a “Internship in MD program”. Students that come from foreign countries, however, can be excused from the overseas internship requirement if they participate in collaborative research with other universities within Japan. Furthermore, at least one of these three internships must be completed during the two years of the Master’s program.

Group 6: Master Course Seminar

* Required credits: 6

These are the seminars conducted within departments that students belong to, and are similar to normal courses in that a master’s thesis must be submitted and an evaluation must be passed in order to be awarded a Master’s degree.

However, training in this program includes all components A) through H) of the Goals for Educational Achievement, and this is positioned as a mid-term evaluation of the level to which the student has incorporated the skills related to each goal. It is extremely important for both academic advisors and students to strongly aware of how this is positioned when working on these goals, and this information is made known during entrance orientations.

Students undergo the doctoral skills assessment (Qualifying Examination 1; QE1) before completing the second year of the Master’s program. While a written examination is conducted based on academic performance, credits earned, English language skills (TOEFL, etc.) and training project report scores up to that point, interview examinations are also conducted to assess skills at setting up research topics and English communication ability. Only students who pass this assessment are allowed to proceed to the third year (Doctoral program) of the program.

Third, Fourth and fifth year (equivalent to the Doctoral course)

Group 7: Expansion Subjects for MD Materials Science and Engineering

*Required credits: 4 or more

This is a course group consisting of “Special Lecture for Practical Science and Engineering I through IV”, where students can learn in greater depth and detail about principles and practical application of evaluations and analysis methods when manufacturing devices and materials for actual use.

Group 8: Practical Application Subjects for MD Materials Science and Engineering

*Required credits: 2 or more

This course group consists of “Seminar and Practice for Industry-Academia Cooperation”, and other such events. It allows students the chance to learn about basic principles and processes for the technology surrounding the topic of their doctoral dissertation research.

Group 9: Internships II

*Required credits: 6

This is the next stage after “Internships I” from the Master’s program. Students must experience all three of the “Internship in MD program”, “Internship in Industries”, and “Internship in Overseas” over the course of five years.

Group 10: Overviews

* Required credits: 2 (compulsory)

Students must compile literature, make classifications, and cover the points that were clarified while discussing what future topics can be derived in regards to the research that they have conducted for both the topic of the doctoral dissertation research in their specialized area, and the topic of the research conducted at the laboratory of their “Internship in MD program”. As such, they must undergo assessment through discussion with the person in charge of the collaboration at the company they are matched with for their company internship, as well as the person in charge of their intra-program internship research at the laboratory where it is conducted (sub-adviser). It is recommended to post the overview report to international academic journals.

Group 11: Doctoral training

* Required credits: 8 (compulsory)

These are the training courses that MD students undergo in the area of specialization that they belong to. They are the same as normal courses in that students are awarded their doctoral degree when they submit a doctoral dissertation and pass an examination. In addition, they are more than just doctoral training courses for MD students. That is to say, similar to course group (6), the courses also evaluate the level to which students have incorporated skills related to each of the educational goals. It is extremely important for both educators and students in the program to strongly aware of how this course group is positioned when working on these goals, and this information is made known during entrance orientations.

In addition to the examination in the department where MD students belongs to, MD program and the Degree Reviewing Committee conducts overall assessments including QE2 (Qualifying Examination 2). This overall assessments involve a special examiner such as, researchers from

foreign countries as well as from the business sector. Students receive final recognition of having completed MD program by passing both the specialized examination and the overall assessment. The quality of the student's specialized expertise and broad vision and knowledge are both assured by satisfying these completion requirements.

The university supports the careers of students who have completed the program through collaboration with its existing organizations, the Program in Emergent Innovation, and ILP- Innovative Leaders Platform. Lectures at the Program in Emergent Innovation are focused on building practical application abilities and people skills, and aim to help attendees attain practical expertise and ways of thinking. These lectures help broaden the realm of future career possibilities for attendees.

Figure 3 illustrates the basic structure of the program.

Figure 3



(4) Conferment of Academic Certifications

This program bestows the academic certification of doctor for the department to which the student belongs. Evaluation criteria are based on the assessments of departments for solid academic performance. Also, this program differs from traditional graduate school education, aiming to develop vision and comprehensive knowledge pertaining to materials in addition to extensive knowledge and experience in one particular field. As such, assessments are conducted by the Degree Reviewing Committee within the Division for Leading Graduate School Programs, Tohoku University Institute for Promoting Graduate Degree Programs. “Completed Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders in the Program for Leading Graduate Schools” is inscribed on the doctoral course diploma.

4. Study Categories for the Interdepartmental Doctoral Degree Program for Multi-dimensional Materials Science Leaders

(1) Master's Program Course Groups

Category	Course	Credit		Required credits	Basic Schedule	
		Compulsory	Elective		MC1	MC2
Group 1 Basic Subjects for MD Material Science and Engineering	Introduction to MD Material Science and Engineering	1		6 or more credits (include 2 compulsory credits)		
	Ethics for Scientist	1				
	MD Fundamental Material Physics		2			
	MD Fundamental Material Chemistry		2			
	MD Fundamental Material Mathematics		2			
	Introduction to Frontier Sciences for Advanced Environment		2			
	Special Lecture for Social Science		2			
	Economics for Multi- Dimensional Material Science		2			
	Game Theory for Multi – Dimensional Material Science		2			
Group 2 Major Basic/General Subjects	Those approved by the department you belong.			10 or more credits		
Group 3 Expansion Subjects for MD Material Science and Engineering	Practical Material Science and Engineering I		2	10 or more credits		
	Practical Material Science and Engineering II		2			
	Practical Material Science and Engineering III		2			
	Practical Material Science and Engineering IV		2			
	Practical Material Science and Engineering V		2			
	Practical Material Science and Engineering VI		2			
	Practical Material Science and Engineering VII		2			
	Practical Material Science and Engineering VIII		2			
	Practical Material Science and Engineering IX		2			
	Practical Material Science and Engineering X		2			
Group 4	MD Training for Global Communication Skill I	1				

Qualifying Examination 1; QE1

Applied Subjects for MD Material Science and Engineering	MD Training for Global Communication Skill II	1		4 compulsory credits			
	Lecture for Safety Management and Control of Organization I	1					
	Lecture for Leadership Education I	1					
Group 5 Internships I *2	Internship in Industries		1~2	2 or more credits			
	Internship in Overseas		1~2				
	Internship in MD program		1~4				
Group 6 Master Course Seminar	Master Course Seminar	6		6 compulsory credits			
Related Courses	Those approved by the Center for Education and Research on Multi-dimensional Materials Science Basic Education Committee.						

Students are required to earn 38 or more credits of the subjects mentioned above.

(2) Doctoral Program Course Groups

Category	Course	Credit		Required credits	Basic Schedule			
		Compulsory	Elective		DC1	DC2	DC3	
Group 7 Expansion Subjects for MD Materials Science and Engineering *1	Special Lecture for Practical Science and Engineering I		2	4 or more credits				Qualifying Examination 2; QE2
	Special Lecture for Practical Science and Engineering II		2					
	Special Lecture for Practical Science and Engineering III		2					
	Special Lecture for Practical Science and Engineering IV		2					
Group 8 Practical Application Subjects for MD Materials Science and Engineering	Seminar and Practice for Industry-Academia Cooperation I		1	2 or more credits				
	Seminar and Practice for Industry-Academia Cooperation II		1					
	Special Lecture for MD Materials Science and Engineering		1					
	MD Training for Global Communication Skill III		1					
	MD Training for Global Communication Skill IV		1					
Group 9 Internships II	Internship in Industries		1~2	6 credits				
	Internship in Overseas		1~2					

*2	Internship in MD program		1~4				
Group 10 Overviews	Overview I (Research focus of Doctoral Dissertation)	1		2 compul -sory credits			
	Overview II (Research focus of Internship in MD Program)	1					
Group 11 Doctoral Course Seminar	Doctoral Course Seminar	8		8 compul -sory credits			
Related Courses	Those approved by the Center for Education and Research on Multi-dimensional Materials Science Basic Education Committee as Related Subjects.						

Students are required to earn 22 or more credits of the subjects mentioned above.

*1: “Special Lecture for Practical Science and Engineering I” through “Special Lecture for Practical Science and Engineering III” categorized in the “Expansion Subjects for MD Materials Science and Engineering” shall be able to be applied in place of the corresponding courses in the student’s field of specialization.

*2: For “Internships I” and “Internships II”, any course credits in excess of 2 that are earned for “Internships I” shall be able to be applied as credits for “Internships II”.

Provided, however, that students earn a total from “Internships I” and “II” of 2 credits each for the “Internship in Industries” and “Internship in overseas”, and 4 credits for the “Internship in MD program”.

“Internship in Industries” is considered to be one part of collaborative research with companies, and it is advised to do it during the Doctoral program.