

## Materials Engineering

**Degree :** Doctor of Philosophy (Materials Engineering)  
Ph.D. (Materials Engineering)

### **Curriculum Structure : Plan 1.1**

The degree of Doctor of Philosophy (Materials Engineering) consists of 48 credits, including 48 credits of doctoral thesis and at least 7 credits auditing of major taught courses.

1. Minimum of 7 credits auditing of major taught courses composing of
  - 1.1 4 credits of seminar
  - 1.2 3 credits of core major courses
2. Minimum of 48 credits in a doctor thesis

### **Course List**

#### **1. Minimum of 7 credits auditing of major taught courses**

##### **1.1 4 credits of seminar**

01213697	Seminar	1,1,1,1
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##### **1.2 3 credits of core major courses**

01213691	Advanced Research Methods in Materials Engineering	3 (2-3-6)
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#### **2. Minimum of 48 credits in a doctor thesis**

01213699	Thesis	1-48
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### **Curriculum Structure : Plan 1.2**

The degree of Doctor of Philosophy (Materials Engineering) consists of 72 credits, including 72 credits of doctoral thesis and at least 9 credits auditing of major taught courses.

1. Minimum of 9 credits auditing of major taught courses composing of
  - 1.1 6 credits of seminar
  - 1.2 3 credits of core major courses
2. Minimum of 72 credits in a doctor thesis

**Engineering****Course List****1. Minimum of 9 credits auditing of major taught courses****1.1 6 credits of seminar**

01213697	Seminar	1,1,1,1,1,1
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**1.2 3 credits of core major courses**

01213691	Advanced Research Methods in Materials Engineering	3 (2-3-6)
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**2. Minimum of 72 credits in a doctor thesis**

01213699	Thesis	1-72
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**Curriculum Structure : Plan 2.1**

The degree of Doctor of Philosophy (Materials Engineering) consists of 48 credits, including 36 credits of doctoral thesis and at least 12 credits of major taught courses.

## 1. Minimum of 12 credits of major taught courses composing of

1.1 4 credits of seminar

1.2 3 credits of core major courses

1.3 5 credits of elective major courses

## 2. Minimum of 36 credits in a doctor thesis

**Course List****1. Minimum of 12 credits of major taught courses****1.1 4 credits of seminar**

01213697	Seminar	1,1,1,1
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**1.2 3 credits of core major courses**

01213691	Advanced Research Methods in Materials Engineering	3 (2-3-6)
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**1.3 5 credits of elective major courses**

01213611	Advanced Materials Characterization	3 (3-0-6)
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01213621	Modern Metallurgy	3 (3-0-6)
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01213631	Advanced Crystallography of Materials	3 (3-0-6)
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01213641	Computational Simulation in Advanced Polymer Processing	3 (3-0-6)
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01213696	Selected Topics in Materials Engineering	1-3
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01213698	Special Problems	1-3
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**2. Minimum of 36 credits in a doctor thesis**

01213699	Thesis	1-36
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**Engineering****Curriculum Structure : Plan 2.2**

The degree of Doctor of Philosophy (Materials Engineering) consists of 72 credits, including 48 credits of doctoral thesis and at least 24 credits of major taught courses.

1. Minimum of 24 credits of major taught courses composing of
  - 1.1 6 credits of seminar
  - 1.2 10 credits of core major courses
  - 1.3 8 credits of elective major courses
2. Minimum of 48 credits in a doctor thesis

**Course List****1. Minimum of 24 credits of major taught courses****1.1 6 credits of seminar**

01213697	Seminar	1,1,1,1,1,1
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**1.2 10 credits of core major courses**

01213513	Thermodynamics and Kinetics of Materials	4 (4-0-8)
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01213514	Materials Characterization in Research	3 (3-0-6)
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01213591	Research Methods in Materials Engineering (auditing)	3 (3-0-6)
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01213691	Advanced Research Methods in Materials Engineering	3 (2-3-6)
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**1.3 8 credits of elective major courses**

Enroll in at least 8 credits in the following courses, of which at least 5 credits should be

012136xx.

01213522	Advanced Metallurgical Extraction Technology	3 (3-0-6)
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01213523	Advanced Welding Technology	3 (3-0-6)
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01213524	Corrosion Failure Analysis and Prevention	3 (3-0-6)
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01213526	Advanced Powder Metallurgy	3 (3-0-6)
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01213527	Alloy Technology	3 (3-0-6)
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01213528	Fatigue and Surface Optimization	3 (3-0-6)
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01213529	Advanced Mechanical Behavior of Materials	3 (3-0-6)
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01213531	Bioceramics	3 (3-0-6)
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01213532	Advanced Electroceramic Materials	3 (3-0-6)
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01213533	Crystallography of Materials	3 (3-0-6)
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01213534	Materials for High Temperature Applications	3 (3-0-6)
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01213545	Polymer Physics	3 (3-0-6)
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01213546	Inorganic and Organometallic Polymers	3 (3-0-6)
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01213547	Mechanical Properties of Solid Polymers	3 (3-0-6)
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**Engineering**

01213548	Degradation of polymer	3 (3-0-6)
01213549	Biopolymers	3 (3-0-6)
01213551	Advanced Composite Materials	3 (3-0-6)
01213552	Nanoengineering	3 (3-0-6)
01213553	Advanced Biomaterials	3 (3-0-6)
01213565	Advanced Metal Processing	3 (3-0-6)
01213566	Advanced Ceramics Processing	3 (3-0-6)
01213567	Advanced Polymer Processing and Rheology	3 (3-0-6)
01213568	Microelectronic and Microsystem Technology and Fabrications	3 (3-0-6)
01213569	Electrochemical Engineering for Industrial Materials and Waste Management	3 (3-0-6)
01213577	Product Life Cycle Design and Management for Materials Engineer	3 (3-0-6)
01213578	Industrial Organization and Management for Materials Engineer	3 (3-0-6)
01213579	Quality Engineering Analysis for Materials Engineer	3 (3-0-6)
01213611	Advanced Materials Characterization	3 (3-0-6)
01213621	Modern Metallurgy	3 (3-0-6)
01213631	Advanced Crystallography of Materials	3 (3-0-6)
01213641	Computational Simulation in Advanced Polymer Processing	3 (3-0-6)
01213696	Selected Topics in Materials Engineering	1-3
01213698	Special Problems	1-3
<b>2. Minimum of 48 credits in a doctor thesis</b>		
01213699	Thesis	1-48

**Engineering****Course Description****01213513 Thermodynamics and Kinetics of Materials 4 (4-0-8)**

Classical and statistical thermodynamics. Equilibrium state and phase diagrams. Behavior of gases and solutions. Chemical reaction. Free energy. Empirical kinetics. Kinetics of ideal systems. Non-isothermal reactions. Thermal analysis techniques. Crystallization. Transport phenomena of materials.

**01213514 Materials Characterization in Research 3 (3-0-6)**

Principle of x-ray diffractometry. Applications of x-ray diffractometry in researches. Hands-on practice in x-ray diffractometer operation. Principle of scanning electron microscope. Applications of scanning electron microscope in researches. Qualitative and quantitative chemical analysis by energy dispersive spectroscopy. Hands-on practice in scanning electron microscope operation. Principle of transmission electron microscope. Sample preparation for transmission electron microscope. Principle of electron diffractometry. Structural analysis of materials by electron diffractometry.

**01213522 Advanced Metallurgical Extraction Technology 3 (3-0-6)**

Extraction technology, decompositions of each type of metals, industrial extraction of metals, and metal recycling.

**01213523 Advanced Welding Technology 3 (3-0-6)**

Welding technology, characteristics of fusion, physical metallurgy of welds, failure of welded structures, failure control and prevention in welds, joining of steels, joining of non-ferrous metals, advanced technology in welding, reliability of welded structures, behaviors of welds in service.

**01213524 Corrosion Failure Analysis and Prevention 3 (3-0-6)**

Principles of corrosion. Forms and mechanisms of corrosion. Corrosion prevention by cathodic protection and coatings. Materials selection and design. Corrosion testing methods. Corrosion failure analysis.

**01213526 Advanced Powder Metallurgy 3 (3-0-6)**

Principle and application of powder metallurgy. Powder characterization techniques. Control of powder production for desired properties. Rule of powder mixing. Powder consolidation and forming. Sintering and heat treatment. Finishing operations. Powder metallurgy product design. Advanced processing techniques and industrial process design. Case study.

**Engineering**

- 01213527 Alloy Technology 3 (3-0-6)**  
Development of alloy technology. Production of ferrous and non-ferrous metals. Ferrous and non-ferrous alloys. Development and application of modern alloys. Amorphous alloys. Nanocrystalline alloys. Alloys in industrial applications. Alloy design.
- 01213528 Fatigue and Surface Optimization 3 (3-0-6)**  
Fatigue of metals. Fatigue failure mechanism. Crack initiation and propagation. Effect of residual stresses. Surface treatments for fatigue prevention.
- 01213529 Advanced Mechanical Behavior of Materials 3 (3-0-6)**  
Mechanical properties and testing. Stress and strain analysis. Fracture and fracture mechanics. Applications of metals and their failure. Case study.
- 01213531 Bioceramics 3 (3-0-6)**  
Characteristics and properties of bioceramics. Biocompatibility with human bodies. Applications of bioceramics in medicine and dentistry. Case study.
- 01213532 Advanced Electroceramic Materials 3 (3-0-6)**  
Physical and chemical principles of ceramic conductors. Dielectric ceramics and ceramic superconductors. Relationship among structure, processing, microstructure and electrical properties of ceramics. Synthesis and forming processes of electroceramic materials. Applications of electroceramic materials.
- 01213533 Crystallography of Materials 3 (3-0-6)**  
Crystal structures concepts. Crystal structures classifying. Symmetry in crystal structures. Relationships between crystal structures and mechanical, electrical, optical, and magnetic properties of materials.
- 01213534 Materials for High Temperature Applications 3 (3-0-6)**  
Selections of materials for high temperature applications, mechanical behavior, physical metallurgy of superalloys, high temperature ceramics.
- 01213545 Polymer Physics 3 (3-0-6)**  
Polymer molecules. Ideal polymer states. Chain statistics and rheology of polymer solutions and melts. Rubber-like elasticity. Transition to glassy state. Hard amorphous polymers. Polymer crystals. Morphology and thermomechanical responses of partially crystalline polymers.

**Engineering**

- 01213546 Inorganic and Organometallic Polymers 3 (3-0-6)**  
Mechanisms of polymerization and characterizations of inorganic and organometallic polymers.
- 01213547 Mechanical Properties of Solid Polymers 3 (3-0-6)**  
Deformation of elastic solid. Rubber-like elasticity. Linear and non-linear viscoelasticity. Anisotropic mechanical behavior. Polymer composites. Relaxation transitions. Yield behavior of polymers. Breaking phenomena.
- 01213548 Degradation of polymer 3 (3-0-6)**  
Degradation of polymer by heat, light, oxidation, high energy radiation, photo-oxidation, mechanical force, microorganism, and special environment.
- 01213549 Biopolymers 3 (3-0-6)**  
Structure of biopolymers. Application of characterization techniques. X-ray structural analysis. Bio plastic. Biomedical polymer. Bionanotechnology.
- 01213551 Advanced Composite Materials 3 (3-0-6)**  
Processing and design of composite materials, fiber composites, chemical and physical processes.
- 01213552 Nanoengineering 3 (3-0-6)**  
Definition, history and advances in nano-scale science and engineering. Characterization techniques and properties of nano-scale materials. Production processes, applications and examples of nano-scale devices, emphasizing the relationship between structures, properties and applications.
- 01213553 Advanced Biomaterials 3 (3-0-6)**  
Classification and applications of biomaterials. Characterization of biomaterials. Relationships of structure and property of biomaterials. Biocompatibility and toxicity. Biodegradable materials. Design and production. Soft tissue and hard tissue implants.

**Engineering****01213565      Advanced Metal Processing      3 (3-0-6)**

Advanced thermodynamics and phase diagrams. Advanced diffusion and kinetics of phase transformation. Crystal interfaces and interfacial energy. Defects in solids. Nucleation and growth. Alloy solidification. Castings and welding. Diffusional phase transformations in solids. Precipitate growth and age hardening. Diffusionless transformations and martensitic transformation. Interphase mass transfer. Oxide surface formation.

**01213566      Advanced Ceramics Processing      3 (3-0-6)**

Ceramic powder synthesis techniques by comminution, solid state reaction, combustion synthesis, co-precipitation and spray drying. Characterization of ceramic powder. Ceramic fabrication techniques by pressing and injection molding. Principle of slurry preparation and particle interaction. Preparation of ceramic samples from slurry. Thin film preparation. Preparation of single crystal materials for research and industrial applications. Modern technology in sample preparation. Characterization of ceramic samples.

**01213567      Advanced Polymer Processing and Rheology      3 (3-0-6)**

Principle and applications of rheology and measurement. Special injection molding processes. Co-extrusion and related processes. Compression molding processes. Vacuum forming processes. Transport phenomena in polymer processing. Case study. Basic principle of computer-aided-engineering technology in polymer processing.

**01213568      Microelectronic and Microsystem Technology and Fabrications      3 (3-0-6)**

Overview of microelectronic technology. Materials technology for microelectronic applications. Microelectronic devices. Crystal growth. Diffusion and transport phenomena for microfabrication. Thermal oxidation. Impurity doping and ion implantation. Lithography and etching. Physical deposition and chemical vapor deposition. Fundamentals and mechanisms of microsystem and microelectromechanical systems (MEMS). Materials for microsystem and MEMS. Micromanufacturing and surface micromachining.

**01213569      Electrochemical Engineering for Industrial materials and Waste Management      3 (3-0-6)**

Principles of electrochemistry and transport processes. Batteries and fuel-cells. Sensors. Electrowinning and refining of metals. Surface modification by electro/electroless deposition and etching. Metal waste recycling. Electrochemical instrumentations.

**Engineering****01213577 Product Life Cycle Design and Management for Materials Engineer 3 (3-0-6)**

Principle of product life cycle design and management. Product design and development process. Quality function deployment. Design process. Engineering factor for design. Materials selection. Interaction of materials. Processing and design. Product evaluation. Model and thread of product life cycle management. Life cycle analysis. Product life cycle management inside and outside factory. Green Productivity.

**01213578 Industrial Organization and Management for Materials Engineer 3 (3-0-6)**

Internal organization, managerial controls, industrial risk and forecasting, financing industrial enterprise product, research and development, production planning, physical facilities, production and materials control, method improvement, personal management, marketing, advertising and sales promotion, cost control.

**01213579 Quality Engineering Analysis for Materials Engineer 3 (3-0-6)**

Quality engineering concept, product design and specification, process design and planning, design of experiment, materials inspection and testing, measurement tools calibration, failure analysis, quality improvement, failure mode and effect analysis, management system in inspection and testing laboratory.

**01213591 Research Methods in Materials Engineering 3 (3-0-6)**

Principles and research methods in materials engineering, problem analysis for research topic identification, data collection for research planning, identification of samples and techniques. Analysis, interpretation and discussion of research result; report writing for presentation and publication.

**01213611 Advanced Materials Characterization 3 (3-0-6)**

Principle and applications of x-ray diffraction. Qualitative chemical analysis and structural analysis by x-ray diffraction. Principle and applications of scanning electron microscope. Image formation and interpretation. Qualitative and quantitative chemical analysis by energy dispersive spectroscopy. Principle and applications of transmission electron microscope. Sample preparation for transmission electron microscope. Principle of electron diffraction. Structural analysis by electron diffraction. Principle and applications of atomic force microscopy.

**Engineering**

- 01213621 Modern Metallurgy 3 (3-0-6)**  
Roles of metals in modern world. Metallurgy for energy saving and environmental friendly. Phase transformation. Imperfection and properties in metals. Nanocrystalline and amorphous metals. Intermetallics. Superalloys and light-weight metals. Functional alloys. Advanced manufacturing techniques of metals and alloys.
- 01213631 Advanced Crystallography of Materials 3 (3-0-6)**  
Types and symmetry of crystal structures. Diffraction. Structure factor. Reciprocal lattice. Ewald sphere. Crystal orientation. Effect of crystal structure on material properties.
- 01213641 Computational Simulation in Advanced Polymer Processing 3 (3-0-6)**  
Principle and applications of computer-aided-engineering technology in advanced polymer processing. Dimensional analysis and scaling. Transport phenomena in polymer processing. Finite difference method. Finite element method. Boundary element method.
- 01213691 Advanced Research Methods in Materials Engineering 3 (2-3-6)**  
Advanced research materials engineering and preparation of research proposal, application of information technology and computer data processing and retrievals, data analysis, article writing and presentation, group discussion. Paper preparation for presentation and publication.
- 01213696 Selected Topic in Materials Engineering 1-3**  
Selected topic in materials engineering at the doctoral degree level. Topics are subject to change each semester.
- 01213697 Seminar 1**  
Presentation and discussion on interesting topics in materials engineering at the doctoral degree level.
- 01213698 Special Problems 1-3**  
Study and research in materials engineering at the doctoral degree level and compile into a written report.
- 01213699 Thesis 1-72**  
Research at the doctoral degree level and compile into a thesis.