

DEPARTMENT OF METALLURGICAL ENGINEERING

Department of Metallurgical Engineering provides a program of metallurgical and materials engineering. The program is designed to give a broad understanding of all types of materials, including metals, ceramics, and polymers, with the emphasis on metals. The undergraduate course covers the fundamental techniques of science and engineering used in the profession. There are subjects concerning with the basic principles of materials science and engineering, materials processings and formings, materials properties and applications, and designing of materials and processes. The course also has many engineering practice subjects such as various laboratories, engineering project, engineering practice, and industrial visit.

HEAD :

Gobboon	Lothongkum,	Dr-Ing. (F.A.F. Hamburg)
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ASSOCIATE PROFESSORS :

Gobboon	Lothongkum,	Dr-Ing. (F.A.F. Hamburg)
Ekasit	Nisaratanaporn,	Ph.D. (I.C. London)
Tachai	Luangvaranunt,	Ph.D. (Tokyo)
Seksak	Asavavisithchai,	Ph.D. (Nottingham)
Patama	Visuttiptikul,	Ph.D. (Tokyo)

ASSISTANT PROFESSORS :

Ittipon	Diewwanit,	Sc.D. (MIT)
Panyawat	Wangyao,	Ph.D. (T.U. Kosice)
Suvanchai	Pongsugitwat,	M.Eng. (Tokyo)
Mawin	Supradist Na Ayudhaya,	Ph.D. (Carnegie-Mellon)
Boonrat	Lohwongwatana,	Ph.D. (Caltech)

LECTURERS:

Chedtha	Puncreobutr,	Ph.D. (I.C. London)
Jirapon	Khamwannah,	Ph.D. (U.C. San Diego)

**METALLURGICAL AND MATERIALS ENGINEERING
CURRICULUM**

COURSE NO. SUBJECT CREDITS

THIRD SEMESTER

2103213	ENG MECH I	3
2109210	THERMO MAT	3
2109211	PRIN ENG MAT I	3
2109276	ENG MAT LAB	1
2301207	CALCULUS III	3
xxxxxxx	GENERAL EDUCATION	<u>6</u>
		19

FOURTH SEMESTER

2103231	MECH OF MAT I	3
2109212	PRIN ENG MAT II	3
2109213	TRAN PHEN MAT PROC	3
2109277	MAT MANU LAB	1
2603284	STAT PHYS SCIENCE	3
xxxxxxx	GENERAL EDUCATION	3
xxxxxxx	FREE ELECTIVES	<u>3</u>
		19

FIFTH SEMESTER

2102391	ELEC ENG I	3
2102392	ELEC ENG LAB I	1
2109310	CHEM ENG MAT	3
2109321	QC QM MAT	3
2109333	MET MAT	3
2109377	MICROSTRUC LAB	1
xxxxxxx	GENERAL EDUCATION	3
xxxxxxx	FREE ELECTIVES	<u>3</u>
		20

Applicants must take at least 12 credits of electives in which they must select at least one course offered in both two groups including Advanced Processing group and Advanced Materials group . If seminar (2109480) course is chosen, the applicant has to take another course offered in the advance processing group.

**FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS**

COURSE NO. SUBJECT CREDITS

SIXTH SEMESTER

2109334	POLY MAT	3
2109335	CERAMIC MAT	3
2109341	MAT CHAR	3
2109399	IND VISIT	1
2100311	ENGINEERING ESSENTIALS	3 <u>OR</u>
2109336	MAT DAILY LIFE	3
5500208	COM PRES SKIL	3 <u>OR</u>
2109400	COM PRES MET	3
xxxxxxx	ELECTIVES	<u>3</u>
		19

SUMMER SEMESTER

2100301	ENGINEERING PRACTICE	2
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SEVENTH SEMESTER

2109411	MECH BEHAV MAT	3
2109478	MECH TEST LAB	1
2109428	MAT PROC	3
2109430	CORROSION OF METAL	3
xxxxxxx	ELECTIVES	<u>6</u>
		16

EIGHTH SEMESTER

5500308	TECH WRIT ENG	3 <u>OR</u>
2109300	CON VOC MAT	3
2109445	FAIL ANAL	3
2109450	MAT SELECT DESIGN	3
2109488	MET MAT ENG PROJ	3
xxxxxxx	ELECTIVES	<u>3</u>
		15

TOTAL CREDITS FOR GRADUATION = 146

METALLURGICAL ENGINEERING

NAME OF DEGREE

: Master of Engineering
: M. Eng.

HEAD :

Gobboon Lothongkum, Dr.-Ing.(F.A.F.
Hamburg)

ASSOCIATE PROFESSORS :

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Patama Visuttipitukul, Ph.D. (Tokyo)
Seksak Asavavisithchai, Ph.D. (Nottingham)
Tachai Luangvaranunt, Ph.D. (Tokyo)
Ekasit Nisaratanaporn, Ph.D.(I.C. London)

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(Carnegie Mellon)
Boonrat Lohwongwatana, Ph.D. (Caltech)
Panyawat Wangyao, Ph.D.(T.U. Kosice)

LECTURERS:

Chedtha Puncreobutr Ph.D. (I.C.London)
Jirapon Khamwannah Ph.D. (U.C. San Diego)

ADMISSION

The applicant must hold a Bachelor's Degree in Engineering or consent of faculty.

The admitted students whose degrees are not Metallurgical Engineering are required to take at least 15 credits of undergraduate courses in Engineering as approved by the Graduate Program Committee during their studies.

DEGREE REQUIREMENTS

The Program consists of 36 credits of coursework and thesis.

Candidates must earn a minimum of 24 credits of graduate coursework and 12 credits of thesis. The candidate is required to maintain at least a "B" average.

COURSE REQUIREMENTS

1) Required Courses

6 credits

2109601	Thermodynamics and Phase Equilibria in Multicomponent System	3(3-0-9)
2109602	Transport Phenomena in Solids	3(3-0-9)
2109603	Concepts in Metallurgical and Materials Engineering	3(3-0-9)
2109711	Seminar in Metallurgical and Materials Engineering I	S/U
2109712	Seminar in Metallurgical and Materials Engineering II	S/U
2109713	Seminar in Metallurgical and Materials Engineering III	S/U

2) Elective Courses

18 credits

2109504	Advanced Physical Metallurgy I	3(2-3-7)
2109507	Advanced Mechanical Metallurgy.	3(2-3-7)
2109508	Rate Phenomena and Modelling in Process Metallurgy.	3(3-0-9)
2109509	Stainless Steel Technology	3(3-0-9)
2109510	Instrumental Analysis	3(2-3-7)
2109514	Advanced Corrosion	3(3-0-9)
2109515	Quantitative Analysis of Microstructure	3(3-0-9)
2109516	Advanced Topics in Physical Metallurgy	3(3-0-9)
2109517	Composite Materials I	3(3-0-9)
2109518	Surface Technology	3(3-0-9)
2109519	Solidification of Casting	3(3-0-9)
2109520	Physical Ceramics	3(3-0-9)
2109525	Welding Engineering	3(3-0-9)
2109526	Advanced Topics in Chemical Metallurgy	3(3-0-9)
2109527	High Temperature Materials	3(3-0-9)
2109528	Properties of Solids	3(3-0-9)
2109530	Physical Metallurgy of Steels	3(3-0-9)
2109533	Powder Metallurgy	3(3-0-9)
2109535	Cellular Metal	3(3-0-9)
2109536	Advanced Topics in Production Metallurgy	3(3-0-9)
2109537	Tribology of Materials	3(3-0-9)
2109555	Nano and Amorphous Materials	3(3-0-9)
2109605	Physical Chemistry of Iron and Steel Manufacture	3(3-0-9)
2109610	Physical Chemistry of Chemical Metallurgy	3(3-0-9)
2109617	Composite Materials II	3(3-0-9)
2109620	Solution Concentration and Purification	3(3-0-9)
2109623	Fracture Analysis	3(3-0-9)
2109630	Forming Process Analysis	3(3-0-9)
2109659	Aluminium Technology	3(3-0-9)
2109811	Thesis	12 credits

METALLURGICAL ENGINEERING**MAME OF DEGREE**

: Doctor of Engineering
: D. Eng.

HEAD :

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Hamburg)

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Boonrat Lohwongwatana, Ph.D. (Caltech)
Mawin Supradist Na Ayudhaya, Ph.D. (Carnegie Mellon)

LECTURERS:

Chedtha Puncreobutr Ph.D. (I.C.London)
Jirapon Khamwannah Ph.D. (U.C. San Diego)

ADMISSION

1. The applicant must hold a Degree of Master of Engineering or consent of faculty.
2. The other qualifications must meet the regulations of the Graduate School, Chulalongkorn University, which will be annually announced or earned approval to be the candidate by the graduate committee of the Faculty of Engineering.

DEGREE REQUIREMENTS

Number of credit units for graduation not less than 48 credits : 4 credits for core courses and 48 credits for Dissertation.

A student who has fulfilled the requirement of the program and of the Graduate School and satisfactorily pass an oral examination, will be awarded the Degree of Doctor of Engineering.

COURSE REQUIREMENTS

	1) <i>Core Courses</i>	4 credits
2109714	Seminar in Metallurgical and Materials Engineering IV	1(1-0-3)
2109715	Seminar in Metallurgical and Materials Engineering V	1(1-0-3)
2109716	Seminar in Metallurgical and Materials Engineering VI	1(1-0-3)
2109717	Seminar in Metallurgical and Materials Engineering VI	1(1-0-3)
	2) <i>Dissertation</i>	
2109828	Dissertation	48 credits

Study Program for Doctoral Degree in Metallurgical Engineering**First Semester**

2109828	Dissertation	8	Credits
2109714	Seminar in Metallurgical and Materials Engineering IV	1	Credits

Second Semester

2109828	Dissertation	8	Credits
2109715	Seminar in Metallurgical and Materials Engineering V	1	Credits

Third Semester

2109828	Dissertation	8	Credits
2109716	Seminar in Metallurgical and Materials Engineering VI	1	Credits

Fourth Semester

2109828	Dissertation	8	Credits
2109717	Seminar in Metallurgical and Materials Engineering VII	1	Credits

Fifth Semester

2109828	Dissertation	8	Credits
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Sixth Semester

2109828	Dissertation	8	Credits
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Total credits for graduation 48 Credits

COURSE DESCRIPTIONS IN METALLURGICAL AND MATERIALS ENGINEERING (B.ENG.)

2109101 Engineering Materials 3(3-0-6)

Relationship between structures, properties, production processes and applications of main groups of engineering materials; crystal structure of solids; crystal defects; mechanical properties of materials; dislocation and strengthening mechanism of metals; mechanical failure of materials; phase diagram and solid state reaction; fabrication and applications of metals; structure, properties and applications of ceramic; structure, properties and applications of polymers; structure, properties and applications of composite materials; corrosion and degradation of materials; properties and applications of electronic materials; electrical properties of materials; magnetic properties of materials; innovation in material technology.

2109210 Thermodynamics of Materials 3(3-0-6)

First and second laws of thermodynamics; criteria for equilibria in constant pressure processes; free energies as a function of temperature, pressure and chemical potential; numerical calculation of free energies from available thermodynamic data; equilibrium in gas mixtures; equilibrium between condensed phases and gas phases; Richardson's free energy diagram; reduction of oxides and sulphides; activities of various substances in metals and slags; application of thermodynamics to extractive metallurgical processes, smelting and refining, solution behavior.

2109211 Principles of Engineering Materials I 3(3-0-6)

Electron; atomic structure; molecules and bonding; crystal structure; x-ray diffraction in crystalline solid; crystal defects; crystal interfaces and microstructure; solid solution and compound; thermodynamics and phase diagrams; solidification.

2109212 Principles of Engineering Materials II 3(3-0-6)

Condition : *PRER 2109211*

Diffusion; principles of solid-state phase transformation; plastic deformation in crystalline solid recovery, recrystallization, grain growth; strengthening mechanism and microstructural control.

2109213 Transport Phenomena in Materials Processing 3 (3-0-6)

Fluid flow: laminar and turbulent flow, flow and vacuum production; materials and energy balance; energy transport; mass transport.

2109276 Engineering Materials Laboratory 1(0-3-0)

Crystal structure; metallographic sample preparation; macro and microstructure; structure examination; cooling curve.

2109277 Material and Manufacturing Processes Laboratory 3(3-0-9)

Heat treatment of steels; hardening, tempering, full annealing and normalizing; practice in sand mold casting of metals; welding practice.

2109300 Basic Concepts and Vocabulary in Metallurgical and Materials Engineering 3(2-2-5)

Introduction to concepts and technical terminologies of materials used for different machines and industries: automotive, aerospace, ship, power plant and petrochemical; working mechanism of machine components produced from different materials.

2109310 Chemistry of Engineering Materials 3(3-0-6)

Thermodynamics of aqueous solutions; kinetics of leaching and precipitation, pressure leaching and reduction; solvent extraction and ion exchange; principles of electrochemistry of aqueous solutions; conductance and transference; electrolytic cell types and potential; current and energy efficiency; principles of pyrometallurgy, including calculation of the values of thermodynamics functions, calcination, roasting, reduction and reduction at slag-metal interfaces; extraction of ferrous and nonferrous metals.

2109321 Quality Control and Quality Management for Materials Engineering 3(3-0-6)

Quality philosophy; quality management strategies in Materials Engineering, organizing for quality. quality concepts; quality control techniques in Materials Engineering.

2109333 Metallic Materials 3(3-0-6)

Microstructures, properties, and application of ferrous and non-ferrous alloys including plain carbon steels, alloy steels, cast irons, aluminium alloys, copper alloys, and white metals.

2109334 Polymeric Materials 3(3-0-6)

Monomer and polymerization; basic polymer molecular concepts; polymer additives; structures, properties, and application of polymers including thermoplastic, thermoset, elastomer, and composite polymers.

2109335 Ceramic Materials 3(3-0-6)

Structure of ceramic crystals; structure of glass; structural imperfection: structural defects, association of defects, non-stoichiometric solids; properties and application of ceramics in Engineering.

2109336 Materials in Daily Life 3(3-0-6)

Learn different aspects of materials as found in daily life, in various occupations and in suitable applications. Environmentally friendly materials. Full utilization of materials in both efficient sense and aesthetic sense. Topics include materials for design and architecture, fashion, arts and craft materials, biomedical materials and biomaterials, automotive materials and household materials.

2109341 Materials Characterisation 3(3-0-6)

Principles and operation of scanning electron microscopy, transmission electron microscopy, x-ray fluorescence, x-ray diffraction, atomic absorption, emission spectrometer, image analyser; non-destructive testing.

2109377 Microstructure Laboratory 1(0-3-0)

Analysis of microstructure of metallic materials.

2109399 Industrial Visit 1(0-3-0)

Condition : *3rd year student*

Visiting the factories related to metal and materials processings; analyzing the processes and presenting a report of the visit.

**2109400 Communication and Presentation Skills
for Metallurgical Engineers 3(3-0-6)**

Necessary skills needed for a winning presentation performance in various settings: academic presentations, project demonstrations, and job interviews; a systematic approach to a great stress-free presentation and a personal design to effectively interact with an audience, sell their ideas, and share their enthusiasm; workshop dealing with common mistakes, miscues, and unexpected surprises that may arise during any meeting encounter.

**2109411 Mechanical behaviour of Materials
3(3-0-6)**

Condition : PRER 2109212, 2103231

Elastic behaviour; theory of plasticity; dislocation theory; mechanical failure: fractures, fatigue, creep, embrittlement; materials testing: tension, hardness, torsion, impact, fatigue, creep; fracture mechanics; mechanical behaviour of composite materials.

2109428 Materials Processing 3(3-0-6)

Theory and modern development of foundry processes; pattern design; casting design; runner and riser design; finishing and inspection of casting products; causes and elimination of defects and design limitations; injection moulding; rapid solidification; theory and practice of rolling, forging, extrusion, wire and tube drawing, deep drawing; causes and elimination of defects.

2109430 Corrosion of Metals 3(3-0-6)

Principles of corrosion; anode and cathode processes; origin and characteristic of corrosion currents; standard electrochemical series; passivity and protective films; effects of environment on corrosion rate; forms of corrosion; corrosion testing; measures to minimize or protect the corrosion, cathodic protection, inhibitors, coating and non-metallic materials in combating corrosion; other materials degradation; materials selection.

2109445 Failure Analysis 3(3-0-6)

General practice in failure analysis: data collection, non-destructive testing, mechanical testing, macro and micro analysis, determination of failure mechanism; failure mechanisms and related environmental factors: fractures in ductile, brittle and fatigue modes; failure due to creep, corrosion and stress-corrosion, weld decay; defects due to heat treatment, case studies.

2109450 Materials Selection and Design 3(3-0-6)

Criteria and concept in design of component and products and economic consideration; materials selection process; material property charts; effects of composition, processing, and structure on materials properties; properties versus performance of materials; case studies of materials processing and design; case studies of materials selection.

2109478 Mechanical Testing Laboratory 1(0-3-0)

Mechanical properties testing: tension test, bending and torsion test, impact test and hardness test.

**2109488 Metallurgical and Materials
Engineering Project 3(0-6-3)**

Practical interesting projects or problems in various fields of metallurgical and materials engineering.

Course group in Advanced Processing

2109312 Chemical Metallurgy II 3(3-0-6)

Condition : PRER 2109310

Physical chemistry in iron and steel making; blast furnace; steel making processes; direct reduction processes; reaction of carbon, silicon and chromium; removal of sulphur and phosphorus; deoxidation; vacuum degassing of steel; hydro and pyrometallurgy of ores commonly found in Thailand.

2109419 Directional Solidification 3(3-0-6)

Solidification behaviour of ferrous and non-ferrous alloys; modulus of cooling and feeder head calculation; the use of internal and external chills; exothermic anti-piping powder and exothermic feeder head.

2109423 Electroplating 2(1-3-2)

Condition : PRER 2109310

Fundamentals of electrochemistry; technology and control of various electroplating processes including chromium plating, nickel plating, copper plating, tin and tin alloys plating, and zinc and zinc alloys plating.

2109424 Iron-making and Steel-making 2(2-0-4)

Condition : PRER 2109310

Fundamentals of iron-making and steel-making processes including blast furnace, direct reduction, direct smelting, basic oxygen process, electric arc furnace, secondary metallurgy and continuous casting processes; physical chemistry of iron-making and steel-making processes.

2109425 Materials Joining 3(3-0-6)

Introduction to materials joining: soldering, brazing and welding, wetting, solid-phase welding, adhesive joining, joining of ceramic, fusion welding processes, mass and heat flow in fusion welding, metallurgical effects of the weld thermal cycle, weld defect, hot and cold cracking, porosity in welds, residual stress in welds, destructive and non-destructive testing of the joints, safety in welding, welding laboratory demonstration.

**2109454 Computational Materials
Engineering 3(2-3-4)**

Information technology (IT) in materials engineering. Introduction to some basic tools/computer software for programming and computation. Review of heat transfer in solid. Introduction to computational materials engineering with some applications.

2109463 Jewelry Metals and Processing 3(3-0-6)

Gold, Silver and Metals in PGMs, Metals for fashion jewelry. Effects of alloying elements, Metallurgy in jewelry metals. Physical property, Mechanical property, Anti-tarnish property, Jewelry process, Investment casting, Forming processes, Defects in jewelry production and solution methods.

2109480 Seminar 1(1-0-2)

Condition : Consent of Faculty

Presentation and discussion on topics of interest in metallurgical and materials engineering.

**2109496 Special Problems in Metallurgical
and Materials Engineering 3(3-0-6)**

Interesting issues in metallurgical and materials engineering.

2109508 Rate Phenomena and Modeling in Process Metallurgy 3(3-0-9)

Rate of metallurgical processes with engineering application to process simulation and control; special attention to processes important to iron and steelmaking homogeneous and heterogeneous reaction kinetics; mass and energy transport; steady-state and nonsteady-state reaction systems; development of process models.

2109510 Instrumental Analysis 3(2-3-7)

Operation principles of transmission electron microscopy and scanning electron microscopy, X-ray diffraction, X-ray fluorescence, atomic absorption and spectro analysis, ESCA and Auger electron spectrometer; interpretation of instrumental results in terms of mechanical properties,

2109516 Advanced Topics in Physical Metallurgy 3(3-0-9)

Advanced topics of current research interests in physical metallurgy.

2109518 Surface Technology 3(3-0-9)

Carburizing, nitriding, flame hardening, diffusion hardening; chemical vapor deposition and physical vapor deposition; electroplating; hot dip coating; metal spraying and ion implantation.

2109519 Solidification of Casting 3(3-0-9)

Study of solidification of metal in molds; characteristics of liquid-solid phase transformations; Sand and metal thermal behavior; macroscopic structures; mechanical properties, and casting defects.

2109525 Welding Engineering 3(3-0-9)

Types and processes of welding; mass and heat flow during welding; metallurgy effects of heat thermal cycle; solid-phase welding and joining of ceramics; welding of ferrous and non-ferrous metals; behavior of welds in service.

2109526 Advanced Topics in Chemical Metallurgy 3(3-0-9)

Advanced topics of current research interests in chemical metallurgy.

2109536 Advanced Topics in Production Metallurgy 3(3-0-9)

Advanced topics of current research interests in production metallurgy.

2109537 Tribology of Materials 3(3-0-9)

Solid lubrication and surface treatment; fundamentals of contacts between solids; abrasive, erosive, and cavitation wear; adhesion and adhesive wear, corrosive and oxidative wear; fatigue wear; fretting and minor wear mechanism; wear of non-metallic materials; case study.

Course group in Advance Materials

2109381 Superalloys 3(3-0-6)

Types of superalloys, production processes and its microstructures, superalloys applications. The relationship among heat treatments, forming processes, microstructures and mechanical properties at high temperatures of nickel, cobalt and iron based superalloys, HIP restoration, microstructure analysis by SEM and TEM.

2109426 Engineering Ceramic Manufacturing Process 3(3-0-6)

Ceramic manufacturing process; ceramic raw materials; ceramic powder synthesis; body preparation; rheology; organic additives; thermal process; sintering; slip casting; tape casting; extrusion; injection moulding; pressing; porous ceramic; sol-gel process; ceramic matrix composite; research and development of engineering ceramic manufacturing process.

2109432 Refractory Materials 3(3-0-6)

Classification of refractory materials; properties of important refractory materials; application of refractories in materials processing units; failures of refractories in materials processing units.

2109433 Electronic Materials 3(3-0-6)

Elementary quantum physics; the band theory of solids semiconductors; semiconductor devices; dielectric materials and insulation; superconductivity.

2109434 Technology Development of Advanced Materials for Medical Application 3(3-0-6)

Properties and types of materials for medical uses; mechanical, structural, chemical and biological characterization; production technology and formation of materials for medical application; research and technology development for advanced materials; advanced material used as biosensor; future trends in biomedical engineering.

2109435 Defects in Solids 3(3-0-6)

Point defects; thermodynamics of point defects; extended defects; structural aspects of composition variation; defects and diffusion; intrinsic defect and extrinsic defect in insulators, nonstoichiometry and intrinsic electronic conductivity, nonstoichiometry and extrinsic electronic conductivity; magnetic and optical defects.

2109491 Materials and Sustainable Development 3(3-0-6)

Principles of sustainability analysis; sustainability indexes; materials technology and nanotechnology enabling sustainable development sustainability in materials production; renewable energy; fuel cell; photovoltaic; bioenergy; green-house gas emissions; sustainable environment; materials life cycle analysis; materials recycling.

2109494 Selected Topics in Metallurgical and Materials Engineering 3(3-0-6)

Topics of current interest and new development in various fields of metallurgical and materials engineering.

2109504 Advanced Physical Metallurgy I 3(2-3-7)

Classification of phase transformations continuous and discontinuous precipitation from solid solution; eutectoidal transformation, massive and martensitic transformation, order-disorder changes; relation of properties to microstructure; techniques and methodology used to study microstructure.

2109509 Stainless Steel Technology 3(3-0-9)

Stainless steel development; stainless steel grades; phase equilibrium diagram; microstructure and metallography; passive film; martensitic, ferritic, austenitic, duplex and precipitation hardening stainless steels; production technology; improvement of mechanical and corrosion properties and selection.

2109514 Advanced Corrosion 3(3-0-9)
Engineering aspects of corrosion and its control; forms by which corrosion manifests itself; simplified mechanisms of corrosion and methods of combating corrosion; electrode processes; activation, ohmic, and concentration polarization; passivation; potentiostatic studies and alloy design; applications to engineering systems.

2109517 Composite Materials I 3(3-0-9)
Properties of engineering composite materials; types of composite materials; fiber and their interfaces; geometrical properties; elasticity; case studies.

2109520 Physical Ceramics 3(3-0-9)
Physical and chemical process responsible for microstructure development; modern electronic ceramics; structural defects, sintering of ceramics and grain growth; mechanical, thermal, electrical, magnetic properties and dielectric property.

2109527 High Temperature Materials 3(3-0-9)
Theory of alloying and relationship among temperature, structure, and mechanical properties in nickel, cobalt, and iron base alloys; effect of thermomechanical processing; analysis of microstructures by transmission electron microscopy, scanning electron microscopy, X-ray diffraction, and X-ray microprobe.

2109530 Physical Metallurgy of Steels 3(3-0-9)
Condition : Consent of Faculty
Properties of high purity iron; interstitial and substitutional solutes; carbon steels; high strength low alloy steels; thermomechanical treatment of steels; alloy steels; steels for magnetic and electrical application.

2109533 Powder Metallurgy 3(3-0-9)
Preparation and fabrication of metal powder; engineering properties and industrial uses; theory of compaction and sintering.

2109535 Cellular Metal 3(3-0-9)
The structure, manufacturing methods, characterization techniques, mechanics. Physical and mechanical properties of cellular metals; energy absorption; sandwich structures and case studies.

2109555 Nano-structured Materials and Amorphous Materials 3(3-0-9)
Definition and classifications of nano-structured materials and amorphous materials; nanomaterials and amorphous materials in nature; processing pathways in relation to metastability and free energy; zero-dimensional, one-dimensional, two-dimensional and three-dimensional nanomaterials; nanomaterials characterizations; environmental and health impacts of nanomaterials.

COURSES DESCRIPTIONS IN METALLURGICAL ENGINEERING (M.ENG., D.ENG.)

2109501 Physical Metallurgy 3(3-0-9)
Structures of metals; physical properties of single crystals, and polycrystals; defects in crystals; diffusion in metals; recovery recrystallization and grain growth; binary and ternary phase equilibrium diagrams; principles of phase transformation.

2109502 Structures and Properties of Metals 3(3-0-9)
Structures and properties of metals and its alloy; relationship between microstructures and mechanical properties of metals.

2109503 Metallographic Examination 1(3-0-1)
Macro and microscopic examinations of important ferrous and non-ferrous metals.

2109504 Advanced Physical Metallurgy I 3(2-3-7)
Classification of phase transformations continuous and discontinuous precipitation from solid solution; eutectoidal transformation, massive and martensitic transformation, order-disorder changes; relation of properties to microstructure; techniques and methodology used to study microstructure.

2109507 Advance Mechanical Metallurgy 3(3-0-9)
Behavior of metals under simple and combined stress systems; elements of elastic theory, plastic deformation, dislocation theory, strength theories, and fracture; experiment in mechanical metallurgy.

2109508 Rate Phenomena and Modeling in Process Metallurgy 3(3-0-9)
Rate of metallurgical processes with engineering application to process simulation and control; special attention to processes important to iron and steelmaking homogeneous and heterogeneous reaction kinetics; mass and energy transport; steady-state and nonsteady-state reaction systems; development of process models.

2109509 Stainless Steel Technology 3(3-0-9)
Stainless steel development; stainless steel grades; phase equilibrium diagram; microstructure and metallography; passive film; martensitic, ferritic, austenitic, duplex and precipitation hardening stainless steels; production technology; improvement of mechanical and corrosion properties and selection.

2109510 Instrumental Analysis 3(2-3-7)
Operation principles of transmission electron microscopy and scanning electron microscopy, X-ray diffraction, X-ray fluorescence, atomic absorption and spectro analysis, ESCA and Auger electron spectrometer; interpretation of instrumental results in terms of mechanical properties.

2109511 Extractive Metallurgy 3(3-0-9)
Principles of extractive metallurgy; thermodynamics and kinetics of pyrometallurgy including roasting, smelting and refining; physical chemistry of iron and steel-making; principles of hydrometallurgy including thermodynamics of aqueous solutions, kinetics of leaching and precipitation.

2109514 Advanced Corrosion 3(3-0-9)
Engineering aspects of corrosion and its control; forms by which corrosion manifests itself; simplified mechanisms of corrosion and methods of combating corrosion; electrode processes; activation, ohmic, and concentration polarization; passivation; potentiostatic studies and alloy design; applications to engineering systems.

2109515 Quantitative Analysis of Microstructure 3(3-0-9)
Basic probability theory and statistical analysis relevant to the quantitative description of a microstructure stereological relationships and the

mathematical foundation and the microstructural tools needed to quantify the structure; applications of quantitative metallography to problems in failure analysis; solidification, heat treatment, phase equilibria, and deformation behavior.

2109516 Advanced Topics in Physical Metallurgy 3(3-0-9)

Advanced topics of current research interests in physical metallurgy.

2109517 Composite Materials I 3(3-0-9)

Properties of engineering composite materials; types of composite materials; fiber and their interfaces; geometrical properties; elasticity; case studies.

2109518 Surface Technology 3(3-0-9)

Carburizing, nitriding, flame hardening, diffusion hardening; chemical vapor deposition and physical vapor deposition; electroplating; hot dip coating; metal spraying and ion implantation.

2109519 Solidification of Casting 3(3-0-9)

Study of solidification of metal in molds; characteristics of liquid-solid phase transformations; Sand and metal thermal behavior; macroscopic structures; mechanical properties, and casting defects.

2109520 Physical Ceramics 3(3-0-9)

Physical and chemical process responsible for microstructure development; modern electronic ceramics; structural defects, sintering of ceramics and grain growth; mechanical, thermal, electrical, magnetic properties and dielectric property.

2109525 Welding Engineering 3(3-0-9)

Type and process of welding; mass and heat flow during welding; metallurgical effects of heat thermal cycle; solid-phase welding and joining of ceramic; welding of ferrous and non-ferrous metals; behavior of welds in service.

2109526 Advanced Topics in Chemical Metallurgy 3(3-0-9)

Advanced topics of current research interests in chemical metallurgy.

2109527 High Temperature Materials 3(3-0-9)

Theory of alloying and relationship among temperature, structure, and mechanical properties in nickel, cobalt, and iron base alloys; effect of thermomechanical processing; analysis of microstructures by transmission electron microscopy, scanning electron microscopy, X-ray diffraction, and X-ray microprobe.

2109528 Properties of Solids 3(3-0-9)

Atomistic approach of metal physics, crystal structure, lattice vibration, energy band; electric, electronic, optical and thermal properties of metal; electron spins; introduction to basic quantum mechanics.

2109530 Physical Metallurgy of Steels 3(3-0-9)

Properties of high purity iron; interstitial and substitutional solutes; carbon steels; HSLA steel; thermomechanical treatment of steel, alloy steels, steels for magnetic and electrical applications.

2109533 Powder Metallurgy 3(3-0-9)

Preparation and fabrication of metal powder; engineering properties and industrial uses; theory of

compaction and sintering.

2109535 Cellular Metal 3(3-0-9)

The structure, manufacturing methods, characterization techniques, mechanics. Physical and mechanical properties of cellular metals; energy absorption; sandwich structures and case studies.

2109536 Advanced Topics in Production Metallurgy 3(3-0-9)

Advanced topics of current research interests in production metallurgy.

2109537 Tribology of Materials 3(3-0-9)

Solid lubrication and surface treatment; fundamentals of contacts between solids; abrasive, erosive, and cavitation wear; adhesion and adhesive wear, corrosive and oxidative wear; fatigue wear; fretting and minor wear mechanism; wear of non-metallic materials; case study.

2109541 Principles of Metallurgical Processing 3(3-0-9)

Introduction to the science of metallurgy; metallurgical furnaces; refractories; metallurgical fuels; temperature measurement and control; metallurgical calculation; energy and mass balances; analysis of steady and non-steady state processes, heat and mass transfer applied to metallurgical processes.

2109555 Nano-structured and Amorphous Materials 3(3-0-9)

Definition and classification of nano-structured materials and amorphous materials; nanomaterials and amorphous materials in nature; processing pathways in relation to metastability and free energy; zero-dimension, one-dimensional, two-dimensional and three-dimensional nanomaterials; nanomaterials characterizations; environmental and health impacts of nanomaterials.

2109601 Thermodynamics and Phase Equilibria in Multicomponent System 3(3-0-9)

Examination and study of thermodynamics of phase equilibria in multicomponent systems; measurements of thermodynamic activity, graphical presentation of phase equilibrium, solid and liquid solution models, development of equations of state using statistical models.

2109602 Transport Phenomena in Solids 3(3-0-9)

Fick's first and second law and their solutions; continuity equation; diffusion couples; interaction between diffusing atoms rate of diffusion; quantitative analysis of diffusion problems; energy and rate at which solid-state transformation occurs in pure metal and alloys; influences of defects on nucleation and grain growth.

2109603 Concepts in Metallurgy and Materials Engineering 3(3-0-9)

Physical metallurgy aspect to metallurgy and materials engineering which includes crystallography, defects and dislocations; microstructure, phase, phase boundaries and related energies; solidification theories; phase transformations and phase equilibria; continuous and discontinuous precipitations.

2109605 Steel Manufacture 3(3-0-9)

Structure and properties of slags; ionic theory and reactions in slags gas reactions in the blast furnace,

partitioning of solute elements between iron and slag in blast furnace; steelmaking processes; refining slags; oxidation and deoxidation reactions; distribution of sulphur between the slag and the metals; removal of phosphorus from the metal.

2109610 Physical Chemistry of Chemical Metallurgy 3(3-0-9)

Kinetics and mechanisms of reaction in chemical metallurgical systems; high temperature oxidation and reduction; slag metal reactions and other related processes; direct reduction.

2109617 Composite Materials II 3(3-0-9)

Theory of laminate, unidirectional strength of laminate Fiber strength, Short fibrous composite, other topics and case study.

2109620 Solution Concentration and Purification 3(3-0-9)

Study of aqueous solution chemistry including estimation of activity coefficients and complex equilibria calculations; application of solution chemistry of reaction kinetics and mass transfer phenomena in cementation; solvent extraction; and precipitation reactions.

2109623 Fracture Analysis 3(3-0-9)

Deformation and fracture mechanics of engineering materials; fracture, microstructural aspects of fracture toughness; environment-assisted cracking; fatigue crack propagation; analysis of engineering failures.

2109630 Forming Process Analysis 3(3-0-9)

Plastic forming of metals bending, forging rollings forge rolling, drawing; sheet metal forming; forging of complicated shapes; geometry of plastic area; formability; asymmetry of plastic deformation; computer analysis of forming process.

2109659 Aluminium Technology 3(3-0-9)

Physical metallurgy of aluminium and its alloys; productions of aluminium; deformation process such as rolling extrusion ; relationship between microstructure and materials properties of aluminium alloys; recrystallization – recovery ; structural developments from the as cast to the worked and quenched state; surface finishes and treatments.

2109701 Seminar in Metallurgical Engineering I 1(1-0-3)

Condition : Consent of Faculty

Seminar in selected research topics of interest in Metallurgical Engineering.

2109702 Seminar in Metallurgical Engineering II 1(1-0-3)

Condition : Consent of Faculty

Seminar in selected research topics of interest in Metallurgical Engineering.

2109703 Seminar in Metallurgical Engineering III 1(1-0-3)

Condition : Consent of Faculty

Seminar in selected research topics of interest in Metallurgical Engineering.

2109704 Seminar in Metallurgical Engineering IV 1(1-0-3)

Condition : Consent of Faculty

Selected research topics of interest in Metallurgical Engineering.

2109705 Seminar in Metallurgical Engineering V 1(1-0-3)

Condition : Consent of Faculty

Selected research topics of interest in Metallurgical Engineering.

2109706 Seminar in Metallurgical Engineering VI 1(1-0-3)

Condition : Consent of Faculty

Selected research topics of interest in Metallurgical Engineering.

2109707 Seminar in Metallurgical Engineering VII 1(1-0-3)

Condition : Consent of Faculty

Selected research topics of interest in Metallurgical Engineering.

2109711 Seminar in Metallurgical and Materials Engineering I 1(1-0-3)

Seminar in selected research topics of interest in Metallurgical and Materials Engineering.

2109712 Seminar in Metallurgical and Materials Engineering II 1(1-0-3)

Seminar in Metallurgical and Materials Engineering II

2109713 Seminar in Metallurgical and Materials Engineering III 1(1-0-3)

Seminar in Metallurgical and Materials Engineering III

2109714 Seminar in Metallurgical and Materials Engineering IV 1(1-0-3)

Selected research topics of interest in metallurgical and materials engineering.

2109715 Seminar in Metallurgical and Materials Engineering V 1(1-0-3)

Selected research topics of interest in metallurgical and materials engineering.

2109716 Seminar in Metallurgical and Materials Engineering VI 1(1-0-3)

Selected research topics of interest in metallurgical and materials engineering.

2109717 Seminar in Metallurgical and Materials Engineering VI 1(1-0-3)

Selected research topics of interest in metallurgical and materials engineering.

2109811 Thesis 12 Credits

2109828 Dissertation 48 Credits

2109894 Doctoral Dissertation Seminar 0(0-0-0)

2109897 Qualifying Examination 0(0-0-0)