

## NANO ENGINEERING CURRICULUM (INTERNATIONAL PROGRAM)

Nanotechnology can be applied in almost all industries and can increase a country's competitiveness. In some industries, nanotechnology is a means for survival. Despite the eminent threat of being left behind, many firms or nations cannot harvest the full potential of nanotechnology due to its multidisciplinary nature and the heavy investment involved in research and development. Our nano-engineering program is such an investment and is truly multidisciplinary in that it ingrains in students the basics (physics, chemistry and biology) and the applied (electrical, optical, biomedical and materials engineering). Most of the current science and engineering degrees are highly fragmented, with little collaboration among departments, resulting in scientists who are too theoretical-minded or engineers who are weak in the sciences. The increased knowledge base and skills required to compete mean that the engineers have to have stronger fundamentals in the sciences and the scientists have to have more hands-on experience. The nano-engineering program is thus formulated to bridge the capability gap of the two.

The nano-engineering program aims to produce undergraduates who are knowledgeable in the fundamental building blocks of nanotechnology through the two majors including Bio-Engineering major and Advanced Material Engineering major. Both majors will provide a strong background in chemical, electrical, optical, biomedical, and material areas in which developments on the nanoscale are becoming a major force for technological improvement. Upon graduation, students will be a unique and important contributor to the human resource pool. They will be capable of developing many manufacturing and service industries and taking them to the next level. The students will possess problem-solving and analytical skills typical of engineers and at the same time have a deep understanding of sciences and materials, especially ones with size scale in the nano-meter range. These will be necessary for providing industries with solutions that are novel and better than existing ones.

The nano-engineering program aims to meet the industries' needs for engineers that are conversant in the various aspects of nanotechnology. Those who graduate from the program can be counted on by virtually all those that are involved in high value-added manufacturing and by most service providers in hi-tech industries to help them gain a sustainable competitive advantage. The graduates from this program can be relied upon for their strong scientific knowledge, practical engineering skills and effective management skills required to lead organizations into the ever increasing competitive world. Each student is required to accumulate a minimum of 147 credits to graduate for Bachelor of Engineering Program in Nano-Engineering (International Program) which also includes 2 credits of industrial training and 4 credits of senior project.

Nano Engineering curriculum has offered two majors in Advanced Materials Nano-Engineering and Bio-Nano Engineering. By which, all students have to make a decision on their field in the third semester.

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### Curriculum board

Asst. Prof. Charusluk Viphavakit	Ph.D.	Chair
Prof. Artiwan Shotipruk	Ph.D.	Committee
Jirapon Khamwannah	Ph.D.	Committee
Chee Keong Ngaw	Ph.D.	Committee
Apipon Methachittipan	Ph.D.	Committee
Porpin Pungetmongkol	Ph.D.	Secretary

### Lecture

Apipon Methachittipan	Ph.D.
Boonchuay Supmonchai	Ph.D.
Assoc. Prof. Chanchana Tangwongsan	Ph.D.
Asst. Prof. Charusluk Viphavakit	Ph.D.
Chatchai Srinitiwarawong	Ph.D.
Asst. Prof. Chate Patanothai	Ph.D.
Chedtha Puncreobutr	Ph.D.
Chee Keong Ngaw	Ph.D.
Chotiros Surapholchai	Ph.D.
Assoc. Prof. Duangdao Wichadukul	Ph.D.
Asst. Prof. Nipaka Sukpirom	Ph.D.
Nithi Saenarjhan	Ph.D.
Nontivich Tandavanitj	Ph.D.
Assoc. Prof. Nopdanai Ajavakorn	Ph.D.
Asst. Prof. Numpon Insin	Ph.D.
Asst. Prof. Oran Kittithreerapronchai	Ph.D.
Prof. Paitoon Rashatasakhon	Ph.D.
Assoc. Prof. Patama Visuttipitukul	Ph.D.
Asst. Prof. Patchanita Thamyongkit	Ph.D.
Asst. Prof. Peerapat Thongnuek	Ph.D.
Pinunta Rojratsirikul	Ph.D.
Pitaakphong Rattanagraikanakorn	Ph.D.
Asst. Prof. Pongdate Montaganitirud	Ph.D.
Porpin Pungetmongkol	Ph.D.
Richard Lemarie	
Asst. Prof. Rojrit Rojanathanes	Ph.D.
Rujira Wanotayan	Ph.D.
Saran Keeratihatayakorn	Ph.D.
Assoc. Prof. Sarawut Rimdusit	Ph.D.
Sirichai Leelachao	Ph.D.
Asst. Prof. Somsak Pianwanit	Ph.D.
Assoc. Prof. Sorada Kanokpanont	Ph.D.
Assoc. Prof. Sujin Khomrutai	Ph.D.
Assoc. Prof. Supaart Sirikantaramas	Ph.D.
Assoc. Prof. Tachai Luangvaranunt	Ph.D.
Asst. Prof. Tawan Paphapote	
Assoc. Prof. Varawut Tangpasuthadol	Ph.D.

**Curriculum**

Total number of credits requirement 147 credits

General Education 30 credits

Core Courses 111 credits

Basic Mathematics and Sciences 29 credits

Compulsory for Nano Engineering 49 credits

Compulsory for Major

A. Bioengineering 18 credits

B. Advanced Material Engineering 21 credits

Approved Electives

A. Bioengineering 15 credits

B. Advanced Material Engineering 12 credits

Free Electives 6 credits

**1. General Education 30 credits**

Social Science 3 credits

Humanity 3 credits

Interdisciplinary 3 credits

Science and Mathematics 3 credits

General Education (Special) 6 credits

2140111 Exploring Engineering World 3(3-0-6)

2141100 Introduction to Nanotechnology 3(3-0-6)

Foreign Language 12 credits

5501112 Communicative English I 3(3-0-6)

5501123 Communicative English II 3(3-0-6)

5501214 Communication and Presentation Skills 3(3-0-6)

5501225 Technical Writing 3(3-0-6)

**2. Core Course 111 credits**Basic Mathematics and Sciences 29 credits

2182201 Mathematics for Nano-Engineering 3(3-0-6)

2301107 Calculus I 3(3-0-6)

2301108 Calculus II 3(3-0-6)

2302103 General Chemistry Laboratory 1(0-3-0)

2302105 Chemistry for Engineers 3(3-0-6)

2302106 Basic Organic Chemistry 3(3-0-6)

2302203 Organic Chemistry Laboratory 1(0-3-0)

2303111 Biology for Engineers 3(3-0-6)

2303112 Biology Laboratory for Engineers 1(0-3-0)

2304153 Physics for Engineers 3(3-0-6)

2304154 Physics and Electronics for Engineers 3(3-0-6)

2304193 Physics Laboratory for Engineers 1(0-3-0)

2304194 Physics and Electronics Laboratory for Engineers 1(0-3-0)

Compulsory for Nano Engineering 49 credits

2140301 Industrial Training 2(0-6-0)

2141290 Statistic and Research Methodology for Nano Engineers 3(3-0-6)

2141302 Nanofabrication Technology 3(3-0-6)

2141485 Nano Capstone 3(0-6-3)

2141490 Nano Seminar 1(1-0-2)

2141498 Nano-Engineering Pre-Project 1(0-2-1)

2141499 Nano-Engineering Project 3(0-6-3)

2182210 Electrical Circuit 3(3-0-6)

2182213 Electric Circuit Laboratory 1(0-3-0)

2182312 Signal Processing and Instrumentation 3(3-0-6)

2183101 Engineering Graphics 3(2-3-4)

2183211 Engineering Mechanics 4(4-0-8)

2184303 Engineering Management 3(3-0-6)

2185222 Physical Chemistry for Nano-Engineering 3(3-0-6)

2185333 Transport Phenomena 3(3-0-6)

2189202 Fundamental of Materials Science and Engineering 3(3-0-6)

2189341 Materials Characterization 3(3-0-6)

2190101 Computer Programming 3(3-0-6)

2190151 Computer Programming Laboratory 1(0-3-0)

Major*A. Bioengineering* 18 credits

2141355 Introduction to Bioengineering 3(3-0-6)

2141357 Cells Biology and Human Body 3(3-0-6)

2189356 Materials for Biomedical Applications 3(3-0-6)

2302207 Basic Inorganic Chemistry 2(2-0-4)

2185373 Reaction Engineering 3(3-0-6)

2310380 Biochemistry for Bioengineers 3(3-0-6)

2310381 Biochemistry Laboratory for Bioengineers 1(0-3-0)

*B. Advanced Material Engineering* 21 credits

2141305 Nanostructures and Crystalline Defects 3(3-0-6)

2185302 Thermodynamics in Materials Engineering 3(3-0-6)

2185379 Polymer Engineering 3(3-0-6)

2189322 Phase Transformations and Kinetics 3(3-0-6)

2189370 Physical Metallurgy 3(3-0-6)

2189411 Mechanical behavior of materials 3(3-0-6)

2189450 Materials Design and Selection 3(3-0-6)

Approved Electives*A. Bioengineering* 15 credits

Select 18 Credits in the following list

2141347 Introduction to Pharmaceutical Nanotechnology 3(3-0-6)

2141407 Nanomaterial Toxicology 3(3-0-6)

2141459 Biointerface Engineering 3(3-0-6)

2141457\* Introduction to Biomedical Imaging 3(3-0-6)

2141458 Introduction to Assistive and Rehabilitation Technology 3(3-0-6)

2141556 Applied Genetic Engineering 3(3-0-6)

2141557 Engineering Systems for Regenerative Medicine 3(3-0-6)

2141561\* Advance Topic in Bioengineering 1 1(1-0-2)

2141562\* Advance Topic in Bioengineering 2 2(2-0-4)

2141563\* Special Topic in Bioengineering 1 3(3-0-6)

2141564\* Special Topic in Bioengineering 2 3(3-0-6)

2141565\* Special Topic in Bioengineering 3 3(3-0-6)

2182450 Biomedical Instrumentation 3(3-0-6)

2183412 Micro and Nano-Electro Mechanical Systems 3(3-0-6)

2183452	Biomechanics	3(3-0-6)
2185379	Polymer Engineering	3(3-0-6)

*B. Advanced Material Engineering* 12 credits

Select 15 Credits in the following list

2141405	Surfaces and Thin Films	3(3-0-6)
2141459	Biointerface Engineering	3(3-0-6)
2141501*	Advance Topic in Advanced Material engineering I	1(1-0-2)
2141502*	Advance Topic in Advanced Material engineering II	2(2-0-4)
2141503*	Special Topic in Advanced Material engineering I	3(3-0-6)
2141504*	Special Topic in Advanced Material engineering II	3(3-0-6)
2141505*	Special Topic in Advanced Material engineering III	3(3-0-6)
2183412	Micro and Nano-Electro Mechanical Systems	3(3-0-6)
2185373	Reaction Engineering	3(3-0-6)
2302389	Intermediate Inorganic Chemistry	3(3-0-6)
2189356	Materials for Biomedical Applications	3(3-0-6)
2189415	Materials for Energy	3(3-0-6)
2189417	Composite materials	3(3-0-6)
2189570	Electronic Materials	3(3-0-6)

**3. Free Electives** **6 credits**

Select 6 credits from any courses offered in English by any International Programs in Chulalongkorn University.



**NANO ENGINEERING CURRICULUM  
(INTERNATIONAL PROGRAM)**

**B. ADVANCED MATERIAL ENGINEERING**

<b>COURSE NO.</b>	<b>SUBJECT</b>	<b>CREDITS</b>	<b>COURSE NO.</b>	<b>SUBJECT</b>	<b>CREDITS</b>
<b>FIRST SEMESTER</b>			<b>FIFTH SEMESTER</b>		
2190101	Computer Programming	3	2189341	Materials Characterization	3
2190151	Computer Programming Laboratory	1	2182312	Signal processing and instrumentation	3
2301107	Calculus I	3	2141305	Nanostructures and Crystalline Defects	3
2140111	Exploring Engineering World	3	2185302	Thermodynamics in Materials Eng	3
2304153	Physics for Engineers	3	2185379	Polymer Engineering	3
2304193	Physics Laboratory for Engineers	1	xxxxxxx	General Education	<u>3</u>
5501112	Communicative English I	<u>3</u>			<u>18</u>
		<u>17</u>			
<b>SECOND SEMESTER</b>			<b>SIXTH SEMESTER</b>		
2141100	Introduction to Nanotechnology	3	2184303	Engineering Management	3
2183101	Engineering Graphics	3	2141302	Nanofabrication Technology	3
2302105	Chemistry for Engineers	3	2185333	Transport Phenomena	3
2302103	General Chemistry Laboratory	1	2189322	Phase Transformations and Kinetics	3
2301108	Calculus II	3	2189370	Physical Metallurgy	3
2304154	Physics and Electronics for Engineers	3	xxxxxxx	General Education	<u>3</u>
2304194	Physics and Electronics Lab for Eng	1			<u>18</u>
5501123	Communicative English II	<u>3</u>			
		<u>20</u>			
<b>THIRD SEMESTER</b>			<b>SUMMER SEMESTER</b>		
2182201	Mathematics for Nano-Engineering	3	2140301	Industrial Training	<u>2</u>
2182210	Electrical Circuit	3			<u>2</u>
2183211	Engineering Mechanics	4			
2189202	Fundamental of Materials Sci and Eng	3			
2302106	Basic Organic Chemistry	3			
2302303	Organic Chemistry Laboratory	1			
5501214	Communication and Presentation Skills	<u>3</u>			
		<u>20</u>			
<b>FOURTH SEMESTER</b>			<b>SEVENTH SEMESTER</b>		
2141290	Statist and Research Methodology for Nano-Eng	3	2141498	Nano - Engineering Pre-Project	1
2182213	Electrical Circuit Laboratory	1	2189411	Mechanical Behavior of Materials	3
2303111	Biology for Engineers	3	xxxxxxx	Approved Electives	3
2303112	Biology Laboratory for Engineers	1	xxxxxxx	Approved Electives	3
2185222	Physical Chemistry for Nano – Eng	3	xxxxxxx	Approved Electives	3
5501225	Technical Writing	3	xxxxxxx	General Education	3
xxxxxxx	General Education	<u>3</u>	xxxxxxx	Free Elective	<u>3</u>
		<u>17</u>			<u>19</u>
<b>FIFTH SEMESTER</b>			<b>EIGHTH SEMESTER</b>		
2190101	Computer Programming	3	2141490	Nano Seminar	1
2190151	Computer Programming Laboratory	1	2141499	Nano Engineering Project	3
2301107	Calculus I	3	2189450	Materials Design and Selection	3
2140111	Exploring Engineering World	3	2141485	Nano Capstone	3
2304153	Physics for Engineers	3	xxxxxxx	Approved Electives	3
2304193	Physics Laboratory for Engineers	1	xxxxxxx	Free Elective	<u>3</u>
5501112	Communicative English I	<u>3</u>			<u>16</u>
		<u>17</u>			
<b>TOTAL CREDITS FOR GRADUATION</b>					<b><u>147</u></b>

## COURSES DESCRIPTIONS IN NANO ENGINEERING (B.ENG)

### General Education (Special)

#### **2140111 Exploring Engineering World 3(3-0-6)**

Engineering topics related to daily life: energy, resources, environment, manufacturing process, industry, material, automotive, infrastructure, information system and bioengineering.

#### **2141100 Introduction to Nanotechnology 3(3-0-6)**

Overview of nanotechnology: What is nanotechnology, Nanotechnology in daily life, fundamental knowledge and its applications, working at nanoscale, trends of nanoscience in industry, life and health.

### Foreign Language

#### **5501112 Communicative English I 3(3-0-6)**

Practice language skills in acquiring information and knowledge from different sources and media in subjects of students' interest under selected themes; collecting information, summarizing and presenting important issues.

#### **5501123 Communicative English II 3(3-0-6)**

**CONDITION: PRER 550112  
Communicative English I**

Practice language skills in acquiring analyzing and synthesizing information and knowledge from different sources and media on topics of students' interest under selected themes; summarizing what they have learned, and presenting opinions from group discussion.

#### **5501214 Communication and Presentation Skills 3(3-0-6)**

**CONDITION: PRER 5501123  
Communicative English II**

Practice using English for social communication and giving oral presentation on engineering-related topics.

#### **5501225 Technical Writing 3(3-0-6)**

**CONDITION: PRER 5501123  
Communicative English II**

Practice in writing summaries composing different types and styles of writing in the field of engineering and writing reports of studies and experiments.

### Core Courses

#### Basic Mathematics and Sciences

#### **2182201 Mathematics for Nano-Eng 3(3-0-6)** **Condition : PRER2301108 Calculus II**

Systems of Linear Equations, Determinants, Vector Spaces, Subspaces, Null Space, Column Space, Row Space, Kernel and Range of a Linear Transformation, Linear Independence, Basis, Coordinate Systems, Dimension, Rank, Change of Basis, Eigenvalues, Eigenvectors, Diagonalization, First-order Differential Equation, Linear Second-order Differential Equation, Reduction of Order, Euler' Equation, Power Series Solution, Frobenius Method, Partial Differential Equation, Boundary Value Problem, Tensor and its Convention, Indicical Notation, Rank of Tensor, Kronecker Delta Tensor, Symmetric and Skew-Symmetric Tensor,

Summation Convention, Tensor Operator, E-Permutation Tensor and its Relationship with Kronecker Delta Tensor, Indicical Manipulation in Vector Calculus, Gradient/Divergence/Curl in Tensor Formulation, Tensor Rotation, Introduction to Quantum Mechanics, Schrodinger's Equation, Particle in a Box, Hermitian, Dirac's Bracket, Eigenvalue, Eigenfunction, Expectation Values, Overview of Nanotechnology, Applications to Scanning Tunneling Microscope Image.

#### **2301107 Calculus I 3(3-0-6)**

Limits; continuity; differentiation; applications of differentiation; integration; applications of definite integral; transcendental functions; techniques of integration; improper integrals; first-order differential equations.

#### **2301108 Calculus II 3(3-0-6)** **CONDITION: PRER 2301107 Calculus I**

Sequences and infinite series; convergence tests; power series; Taylor series; lines; planes, and quadric surface in three-dimensional space; calculus of vector-valued functions; line integrals; limits and continuity of functions of several variables; partial derivatives; directional derivatives and gradients; Lagrange multipliers; multiple integrals.

#### **2302103 General Chemistry Laboratory 1(0-3-0)**

Standard solution preparation; qualitative analysis; titration; electrochemistry; pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

#### **2302105 Chemistry for Engineers 3(3-0-6)**

Structure of atoms; chemical bonding; ionic bonding, covalent bonding, valence bond theory, hybridization-interaction coordination, intermolecular forces, molecular movement; state of matter: gases, structure of solid, liquid, and solutions; chemical reactions; interaction of matters with electromagnetic radiation and electrical energy; chemical thermodynamics.

#### **2302106 Basic Organic Chemistry 3(3-0-6)**

Structure and bonding, stereochemistry, spectroscopy, hydrocarbon, halogen-containing compounds, oxygen-containing compounds, nitrogen-containing compounds, biomolecules.

#### **2302203 Organic Chemistry Laboratory 1(0-3-0)** **CONDITION: PRER 2302103 General Chemistry Laboratory**

Fundamental laboratory techniques concerning the separation, purification and determination of physical constants of organic compounds; Chemical reactions of organic compounds of various functional groups; Synthesis of certain target molecules.

#### **2303111 Biology for Engineers 3(3-0-6)**

Biological principles; cell structures and functions; functions of organelles and sub-cellular structures; chemical basis of life; metabolism and cellular energy processes including regulatory mechanisms; structural organization in relation to functions of organisms; cellular physiology; maintenance the homeostasis of life; continuity of life through inheritance; cellular and molecular basis of

development; molecular genetics; evolution theory and evolution of populations; biological diversity; life responses to environmental changes; biological applications in nanotechnology.

**2303112 Biology Laboratory for Engineers 1(0-3-0)**  
Biological experiments which accord with Biology for Engineer.

**2304153 Physics for Engineers 3(3-0-6)**  
Mechanics of particles and rigid bodies; properties of matter; fluid mechanics; heat; vibrations and waves; elements of electromagnetism; optics; modern physics.

**2304154 Physics and Electronics for Engineers 3(3-0-6)**  
Electricity; DC circuits; AC circuits; basic electronics; solid state devices; electrical actuators.

**2304193 Physics Laboratory for Engineers 1(0-3-0)**  
Measurement and precision; experiments on simple harmonic motion; radius of gyration; dynamics of rotation; velocity of sound; viscosity of fluids.

**2304194 Physics and Electronics Laboratory for Engineers 1(0-3-0)**  
Resistance and electromotive force measurements; experiments on ammeter; voltmeter; oscilloscope; AC circuit; transistor; lenses and mirrors; polarization; interference; diffraction.

#### **Compulsory for Nanoengineering**

**2140301 Industrial Training 2(0-6-0)**  
Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

**2141290 Statistic and Research Methodology for Nano Engineers 3(3-0-6)**  
**CONDITION: PRER 2301108 Calculus II**  
Introduction to random process; Research formulation, research objectives, basic procedure for doing research; Statistical method for research; Analysis of data and its implication; Integration of statistics in engineering applications.

**2141302 Nanofabrication Technology 3(3-0-6)**  
Structure and performance of nanomaterials; Principle of nanostructured materials synthesis, crystal growth, stabilization of nanomaterials; Nanoparticle syntheses; Syntheses of nanowire; Fabrication of thin film, Lithography; Special techniques for nanostructured materials fabrication.

**2141485 Nano Capstone 3(0-6-3)**  
Utilization and application of knowledge in nanoengineering by using scientific research, problem analysis, design, and development to determine possible solutions, question reviews, team collaboration and communication. Apply the project to the real-world problem in the form of group projects.

**2141490 Nano Seminar 1(1-0-2)**  
Seminar on interesting topics related to Nano-Engineering

**2141498 Nano-Engineering Pre-Project 1(0-2-1)**  
Problem-solving framework; Guidelines for problem solving and solution from Nano-Engineering project.

**2141499 Nano-Engineering Project 3(0-6-3)**  
Group or individual project on a subject related to Nano or Bio-Nano-Engineering.

**2182210 Electrical Circuit 3(3-0-6)**  
**CONDITION: PRER 2304154 Physics and Electronics for Engineers**  
DC circuit analysis; Kirchhoff's laws; Thevenin's and Norton's theorem; Semiconductor devices; op-amps; digital circuit; DC motor.

**2182213 Electrical Circuit Laboratory 1(0-3-0)**  
Electronic instruments; Multimeter; oscilloscope; DC circuit; Voltage regulators; Filter circuit; Transistor amplifier circuit; Op-amp circuits; Digital circuits; DC motor.

**2189202 Fundamental of Materials Science and Engineering 3(3-0-6)**  
Atomic structures and bonding in solids; Crystallography; Surfaces and interfaces; Crystal defects; Phase equilibrium diagrams; Solid solution and compounds; Polymeric materials; Amorphous materials; Material properties; Relationship between micro- and nano-structures and properties of engineering materials; Classes of engineering materials, material processing and real-world applications.

**2182312 Signal Processing and Instrumentation 3(3-0-6)**  
**CONDITION: PRER 2182210 Electrical Circuit**  
Basic electromechanical techniques used in modern instrumentation and control systems; Use of transducers and actuators; Signal conditioning, grounding, and shielding; Analog and digital signal processing and feedback control methods with emphasis on frequency domain techniques; Low-level measurements; Lock-in technique frequency response of continuous and discrete systems.

**2183101 Engineering Graphics 3(2-3-4)**  
Lettering; orthographic projections; sketching and drawing; pictorial drawing; dimensioning; tolerancing and geometrical tolerancing; section; working drawing; mechanical parts drawing; introduction to CAD.

**2183211 Engineering Mechanics 3(3-0-6)**  
Analysis of force systems and their equilibrium as applied to engineering systems; Stresses and strains; Mechanical properties of materials; Hooke's law, elastic modulus, stress in beam, shear force, bending moment diagram, torsion, buckling of columns, Mohr's circle.

**2184303 Engineering Management 3(3-0-6)**

Modern management principles; methods of increasing productivity; human relations; industrial safety; pollution problems; commercial laws; basics of engineering economy, finance, marketing, and project management.

**2185222 Physical Chemistry for Nano-Engineering 3(3-0-6)**

Basic concept of thermodynamics; Thermodynamics laws; Phase rule; Phase equilibrium; Principal of chemical kinetics; Rate of chemical reactions; Chemical equilibrium

**2185333 Transport Phenomena 3(3-0-6)**

Viscosity, mathematical models of momentum transports in isothermal fluid systems; Thermal conduction and convection; Mathematical models of energy transports in solids and in fluids for isothermal systems and non-isothermal systems; Diffusion in binary mixtures; Mathematical models of mass transports in isothermal mixtures without chemical reactions and with chemical reactions; Simultaneous mass and energy transports in fluid mixtures.

**2189341 Materials Characterization 3(3-0-6)**

Optical Microscopy, Scanning Probe Microscopy (SPM), Field Emission Scanning Electron Microscopy (FE SEM), Transmission Electron Microscopy (TEM) and Scanning TEM (STEM), Focused Ion Beam (FIB), Energy Dispersive X-Ray Spectroscopy (EDS), X-ray Reflectivity and Total Reflection X-ray Fluorescence, Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectrometry (SMS), Surface Secondary Ion Mass Spectrometry Extended Profile (Surface SIMS XP), Time of Flight Secondary Ion Mass Spectrometry (TOF SIMS), Liquid Chromatography with Mass Spectroscopy (LCMS), Gas Chromatography with Mass Spectroscopy (GCMS), Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray diffraction (XRD).

**2190101 Computer Programming 3(3-0-6)**

Introduction to computer systems; problem-solving using computers; programming style and convention, control statements, data handling and processing; subprograms; classes and objects.

**2190151 Computer Programming Laboratory 1(0-3-0)**

Computer programming in Engineering; reviews of computer programming concepts; hands-on experience on computer programming using contemporary engineering tools.

**Compulsory for Major****A. BIOENGINEERING****2141355 Introduction to Bioengineering 3(3-0-6)**

Introduction to Biological and Biomedical engineering, Engineering of life science and medical technology; Application of biomolecular systems for engineering of cells, biomechanics, biological micro-electromechanical systems (Bio-MEMS), bioinformatics, genomics, bioelectronics, biosensor, bioimaging technology, tissue engineering, drug delivery system, pharmaceutical engineering, etc; The uses of multidisciplinary engineering knowledges in chemical

engineering, electrical engineering, computer engineering, mechanical engineering, metallurgical engineering, environmental, nuclear engineering, etc; Study trips.

**2141357 Cells Biology and Human Body 3(3-0-6)**

Biological mechanisms occurring in a cell that maintain cell activities; Physiological processes of cell in human body, such as membrane transport, neurotransmission and muscle contraction; Basic structure of major organs integrated into various systems in human body; Anatomy and physiology of human body.

**2189356 Materials for Biomedical Applications 3(3-0-6)**

**Condition: PRER 2303111 Biology for engineers, or consent by instructor**

Introduction to the interactions between cells and the surfaces of biomaterials; Surface chemistry and physics of selected metals, polymers, and ceramics; Modification of biomaterials surfaces; Biocompatibility and biodegradability; Medical implants; Acute and chronic response to implanted biomaterials; Recent development in metallic prostheses, biosensors, drug delivery system, tissue engineering and anti-microbial surface.

**2302207 Basic Inorganic Chemistry 2(2-0-4)**

Fundamental concepts in inorganic chemistry; Atomic structure; Chemical periodicity; Chemical bonding and molecular structures; Crystal structures; Inorganic solids; Symmetry and group theory, Molecular orbitals

**2185373 Reaction Engineering 3(3-0-6)**

**CONDITION: PRER: 2302105 Chemistry for Engineers, or consent by instructor**

Fundamental of reaction engineering; reaction rate laws, kinetics, mechanisms of homogeneous and heterogeneous reactions, catalysis reactions, biological reactions, analysis of reaction rate data, basic design of reactors.

**2310380 Biochemistry for Bioengineers 3(3-0-6)**

Fundamental concepts in biochemistry and molecular biology; Chemical and biological properties of biomolecules; Biochemical Reactions; Enzymes; Metabolic Pathways; Molecular genetics; Protein synthesis; Basic of genetic engineering.

**2310381 Biochemistry Laboratory for Bioengineers 1(0-3-0)**

Laboratory in biochemistry and molecular biology including the use of computer programs according to Biochemistry for Bioengineers course. Biochemistry Laboratory for Bioengineers

## **B. ADVANCED MATERIAL ENGINEERING**

### **2141305 Nanostructures and Crystalline Defects 3(3-0-6)**

Laws and theories governing the synthesis and the control of nanomaterial system; Free energy and kinetic principles involved in synthesis, assembly, structure and performance of nanomaterials; Crystal interfaces and structures of nanomaterial; Defects in crystals; Point defects, line defects, planar defects; Motion of dislocations; Effect of impurities on solid-state material properties.

### **2185302 Thermodynamics in Materials Engineering 3(3-0-6)** **CONDITION: PRER 2185222 Physical Chemistry for Nano – Engineering**

Treatment of the first, second and third law of thermodynamics; Free energies as a function of temperature, pressure and chemical potential; Numerical calculation of free energies from available thermodynamic data; Phase equilibria in single- and multi-component systems; Phase diagrams; Electrochemical equilibria and surface thermodynamics; Introduction to statistical thermodynamics; Application of thermodynamics to treat general phenomena in materials engineering.

### **2185379 Polymer Engineering 3(3-0-6)**

Definitions and basic concepts; Crystalline and amorphous polymer; Molecular architecture; Conformation and morphology; Polymer synthesis; Transition phenomena; Mechanical properties affected by transition phenomena; Theory of rubber elasticity; Polymer rheology; Types of mechanical deformations; Basic rheological response; Viscoelastic properties of polymer; Linear viscoelastic models; Synthesis of controlled architecture polymers; Morphological characterization; Block copolymers; Polymer surfaces and interfaces; Nano-effects in polymer blends and composites; Applications of polymer nanotechnology for electronics and photonics

### **2189322 Phase Transformations and Kinetics 3(3-0-6)** **CONDITION: PRER 2185302\* Thermodynamics in Materials Engineering**

Phase equilibrium diagram; Phase transformation; Microstructure evolution; Diffusion; Rates of diffusion; Morphological instabilities; Crystal interfaces; Nucleation and growth; Effects of temperature and driving force on transformations and microstructure; Solid-state diffusion; Spinodal decomposition; Diffusionless transformations and kinetics.

### **2189370\* Physical Metallurgy 3(3-0-6)** **CONDITION: PRER 2189202\* Fundamental of Materials Science and Engineering**

Physical basis that links the structure of materials with their properties; Material processing including casting, welding, thermomechanical processing; Heat treatment; Plastic deformation; strengthening and toughening mechanism in metals and ceramics; Recovery, recrystallization, grain growth; Microstructural control; Oxidation and corrosion.

### **2189411 Mechanical behavior of materials 3(3-0-6)** **CONDITION: PRER 2183211 Engineering Mechanics**

Theory elasticity; theory of plasticity; Dislocation theory; Mechanical failure; Fractures, fatigue, creep, embrittlement; Materials testing; Tension, hardness, torsion, impact, fatigue, creep; Fracture mechanics; Mechanical behavior of composite materials.

### **2189450 Materials Design and Selection 3(3-0-6)**

Criteria and concept in design; Materials selection process; Production and cost functions; Materials property charts, and performance indices; Decision analysis; Case studies of materials design and selection in real-world applications.

## **Approved Electives**

### **A. BIOENGINEERING**

### **2141347 Introduction to Pharmaceutical Nanotechnology 3(3-0-6)**

Importance of nanotechnology in enhancing pharmaceutical technology; Fundamental pharmacokinetics for engineers; Reviews of the types and characteristics of physico-chemical properties of biomaterials produced in Thailand; Fabrication technology of nanomaterials: nanoparticles, micelles, vesicles, liposomes, microemulsions, nanocolloids, polymer multilayers, nanoporous materials and nanocapsules, as well as experimental techniques to characterize these nanomaterials; pharmaceutical technologies.

### **2141407 Nanomaterial Toxicology 3(3-0-6)** **Condition: PRER 2303111 Biology for engineers, or consent by instructor**

Fundamentals of nanotoxicology; Exposure assessment for safe nanotechnology in environment and organisms; Biodistribution of engineered nanomaterials; Nanomaterial interactions with cell, genome and epigenome; Toxicity of nanoengineered materials in systemic organs; Use of nanomaterials in food and cosmetic products; Approach to Regulation of Nanotechnology Products; Laboratory evaluation of potential toxicity of engineered nanomaterials.

### **2141459 Biointerface Engineering 3(3-0-6)** **Condition: PRER 2189356\* Materials for Biomedical Applications, or consent by instructor**

Reviews of cell-material interactions and its applications. Surface energy and thermodynamics of biological molecules; Hydrophobicity of surfaces; Properties of extracellular matrices (ECM) of various types of cells; Cell migration, growth, and differentiation; Blood compatibility of materials; Physical and chemical technics for biosurface modifications; Morphology of surfaces; Evaluation of biocompatibility of materials; Case studies related to biointerfaces engineering such as biomineralization, biosensors, anti-microbial surface etc.

### **2141457 Introduction to Biomedical Imaging 3(3-0-6)**

Various biomedical imaging modalities (x-rays, CT, MRI, ultrasound, PET, SPECT, etc.) and their applications in

medicine and biology; Basic concepts of signal processing in two and three dimensions relevant to imaging physics, image reconstruction, image processing, and visualization.

**2141458 Introduction to Assistive and Rehabilitation Technology 3(3-0-6)**

Problems and basic rehabilitation techniques in various areas, e.g. visual and hearing disability, orthopaedics, stroke, etc.; Human centered concept and design of assistive and rehabilitation devices and technologies; Examples, e.g. wheelchairs, prostheses, hearing aids, visual aids, and specialized computer software and hardware.

**2141556 Applied Genetic Engineering 3(3-0-6)  
Condition: PRER 2310380\* Biochemistry for Bioengineering, or consent by instructor**

Genetic coding; Mutation; Mutagenesis; Gene transfer; Genetically modified organisms (GMOs); Biomolecular engineering; Diagnostic DNA microarray; Large-Scale Protein Production; Antibody design and production for sensors/vaccines; DNA/RNA therapeutic delivery.

**2141557 Engineering Systems for Regenerative Medicine 3(3-0-6)  
Condition: PRER 2303111 Biology for engineers, or consent by instructor**

Basic knowledge of regenerative medicine and tissue regeneration; Components of tissue engineering; Cells and stem cells regeneration, biological signals and molecules, scaffolds, bioreactors, controlled release systems; Analysis and evaluation of tissue regeneration; Case studies in tissue engineering (such as skin, bone, vascular, etc.), cell therapy, drug and gene delivery, medical contrast agents, anti-aging medicine etc.

**2141561\* Advance Topic in Bioengineering 1 1(1-0-2)**

Advance topics in the field of bioengineering

**2141562\* Advance Topic in Bioengineering 2 2(2-0-4)**

Advance topics in the field of bioengineering

**2141563\* Special Topic in Bioengineering I 3(3-0-6)**

Interesting topics in the field of bioengineering.

**2141564\* Special Topic in Bioengineering II 3(3-0-6)**

Interesting topics in the field of bioengineering.

**2141565\* Special Topic in Bioengineering III 3(3-0-6)**

Interesting topics in the field of bioengineering.

**2182450 Biomedical Instrumentation 3(3-0-6)**

Basic concepts of biomedical electronics and instrumentation, e.g. sensors, electrodes, amplifiers, etc.;

Measurement of biopotential signals, heart rate, heart sound, blood pressure, blood flow and oxygen saturation; Therapeutic devices; Electrical safety in medical environment; Trend in biomedical instrumentation.

**2183412 Micro and Nano-Electro Mechanical Systems 3(3-0-6)**

Overview of MEMs; Scaling of micromechanical devices; Behavior and modeling of micromechanical devices; Mechanical properties of MEMs materials; Review of microfabrication; Bulk and surface micromachining; Applications of MEMs: pressure sensors, accelerometer; Micromotors; Micropumps and microvalves; Thermal sensors and actuators; Micromirror.

**2183452 Biomechanics 3(3-0-6)  
Condition : PRER 2304153 Physics for engineers, or consent by instructor**

Introduction to the biomechanics of human movement; Static and dynamic biomechanics; Forces and moments in human posture and movement; musculoskeletal anatomy; knowledge of joint mechanics and example of the analysis and design of artificial joints.

**2185379 Polymer Engineering 3(3-0-6)**

Definitions and basic concepts; Crystalline and amorphous polymer; Molecular architecture; Conformation and morphology; Polymer synthesis; Transition phenomena; Mechanical properties affected by transition phenomena; Theory of rubber elasticity; Polymer rheology; Types of mechanical deformations; Basic rheological response; Viscoelastic properties of polymer; Linear viscoelastic models; Synthesis of controlled architecture polymers; Morphological characterization; Block copolymers; Polymer surfaces and interfaces; Nano-effects in polymer blends and composites; Applications of polymer nanotechnology for electronics and photonics.

**2185452 Biosystems and Biotransport 3(3-0-6)**

Application of fundamental chemical engineering principles in the study of biological systems with emphasis on the current research in bioengineering, biochemical engineering and industrial applications

**2185455 Bioreactor 3(2-1-6)  
Condition: PRER 2185373 Reaction Engineering, or consent by instructor**

Microbiological and enzymatic processes; Stoichiometry and kinetics of biotransformations; Kinetics of cell growth; Basic knowledge of bioreactor design and their cascades; Analysis of bioreactor dynamics; Batch vs. Continuous stirred tank bioreactors; Immobilized cell bioreactors extractive bioreactors; Animal cell and plant cell reactors; Examples of various types of bioreactors in foods, agricultural, environmental, pharmaceutical, and medical applications, such as stirred tank & rotating, packed bed, hollow-fiber, airlift, membrane bioreactors, etc.

**2190456 Introduction to Bioinformatics 3(3-0-6)  
Condition: PRER 2310380\* Biochemistry for Bioengineer, or consent by instructor**

Next Generation Sequencing (NGS) and -omics technologies; -omics data analysis e.g. genomics,

transcriptomics, and proteomics and applications of these technologies in biomedicine e.g. translational medicine, precision/personalized medicine, and drug design.

## **B. ADVANCED MATERIAL ENGINEERING**

### **2141405 Surfaces and Thin Films 3(3-0-6)**

Basic knowledge of modern nanoscale thin film technology; thin film deposition and epitaxial; fundamental of thin film nucleation and growth; emerging thin film materials and applications; various method of surface coating such as thermochemical, plating, fusion and vapor phase process; surface modification and methods to improve properties of coated surface.

### **2141459 Biointerface Engineering 3(3-0-6)**

**Condition: PRER: 2189356\* Materials for Biomedical Applications, or consent by instructor**

Reviews of cell-material interactions and its applications. Surface energy and thermodynamics of biological molecules; Hydrophobicity of surfaces; Properties of extracellular matrices (ECM) of various types of cells; Cell migration, growth, and differentiation; Blood compatibility of materials; Physical and chemical technics for biosurface modifications; Morphology of surfaces; Evaluation of biocompatibility of materials; Case studies related to biointerfaces engineering such as biomineralization, biosensors, anti-microbial surface etc.

### **2141501\* Advance Topic in Advanced Material engineering I 1(1-0-2)**

Advance topics in the field of Advanced Material engineering

### **2141502\* Advance Topic in Advanced Material engineering II 2(2-0-4)**

Advance topics in the field of Advanced Material engineering.

### **2141503\* Special Topic in Advanced Material engineering I 3(3-0-6)**

Interesting topics in the field of Advanced Material engineering.

### **2141504\* Special Topic in Advanced Material engineering II 3(3-0-6)**

Interesting topics in the field of Advanced Material engineering.

### **2141505\* Special Topic in Advanced Material engineering III 3(3-0-6)**

Interesting topics in the field of Advanced Material engineering.

### **2183412 Micro and Nano-Electro Mechanical Systems 3(3-0-6)**

Overview of MEMs; Scaling of micromechanical devices; Behavior and modeling of micromechanical devices; Mechanical properties of MEMs materials; Review of microfabrication; Bulk and surface micromachining; Applications of MEMs: pressure sensors, accelerometer; Micromotors; Micropumps and microvalves; Thermal sensors and actuators; Micromirror.

### **2185373 Reaction Engineering 3(3-0-6) CONDITION: PRER: 2302105 Chemistry for Engineers, or consent by instructor**

Fundamental of reaction engineering; reaction rate laws, kinetics, mechanisms of homogeneous and heterogeneous reactions, catalysis reactions, biological reactions, analysis of reaction rate data, basic design of reactors.

### **2302389 Intermediate Inorganic Chemistry 3(3-0-6)**

Atomic structure and periodicity; molecular geometry and symmetry; introduction to molecular orbital theory; reaction with electron transfer; inorganic solids; structures and bonding of coordination compounds; crystal and ligand field theories; electronic spectra; organometallic chemistry; 18 electron rule; organometallic reactions; applications in industry and medicine.

### **2189356 Materials for Biomedical Applications 3(3-0-6) Condition: PRER 2303111 Biology for engineers**

Introduction to the interactions between cells and the surfaces of biomaterials; Surface chemistry and physics of selected metals, polymers, and ceramics; Modification of biomaterials surfaces; Biocompatibility and biodegradability; Medical implants; Acute and chronic response to implanted biomaterials; Recent development in metallic prostheses, biosensors, drug delivery system, tissue engineering and anti-microbial surface.

### **2189405\* Ceramics and Glasses 3(3-0-6)**

Family of ceramics and glasses; production of advanced ceramics, composites and glasses; bonding and atomic configurations; powder processing, forming, sintering, densification processes, slip casting, blow molding, and material selection and design of compositions based on required properties; additives in ceramics and glasses; characterization of advanced ceramics and glasses; mechanical and reliability tests; applications of advanced ceramics and glasses.

### **2189415 Materials for Energy 3(3-0-6)**

Overview of materials and materials research in the areas of fuel cells, batteries (electrochemical energy conversion and storage), catalysts and membrane separations (fossil fuel and biomass energy conversion), nuclear fuels, supercapacitors, thermoelectrics, solar cells, solar heat and other renewable energy sources; overview of life cycle assessment and material sustainability; applications and future trends.

### **2189570 Electronic Materials 3(3-0-6)**

Electronic, optical and magnetic properties of materials; elementary quantum physics; kinetic molecular theory and thermally activated processes; band structure; electrical conductivity of metals and semiconductors; intrinsic and extrinsic semiconductors; elementary p-n junction theory; doping; dielectric materials and insulation; superconductivity; operating principles of light emitting diodes, solar cells, thermoelectrics, and transistors.

### **2189581\* High Performance Metals 3(3-0-6)**

### **and Alloys**

Overview of physical metallurgy fundamentals to achieving high performance metals, alloys and materials; applications of metals and alloys in petroleum, automotive, electronic, medical and automation industries; light weight metals and alloys for next generation electric vehicles. Metals, alloys and advanced materials using in renewable energy sector such as wind turbine, bearings, solar cells and fuel cells. Biomedical and health applications. Understanding the production processes from conventional to novel techniques: from casting to additive manufacturing, and from machining to laser cutting, etc.

### **2190401\* Computation, Modelling and Problem Solving 3(3-0-6)**

Introduction to modelling and simulation in materials engineering; development and design of models for materials processes and structure-property relations; understanding and prediction of material behavior at scales from atomistic to macroscopic through modelling and simulation; topics include symmetry and structure, thermodynamics, solid state physics, mechanics, phase transformations and kinetics; methods for visualizing solutions and graphical presentation of results.