NANO ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

Nano Engineering program is a multi-disciplinary scheme in which students learn how to understand and engineer various functional systems at the atomic scale. Sub – microsco - pically the physical, chemical, and biological properties of materials are different those of bulk forms in the macroscopic level from Uncovering these unique characteristics propels the groundbreaking research and development of novel applications, making nano - technology the next industrial revolution.

Nano Engineering program aims to develop produce undergraduate students with strong backgrounds in biomedical chemical, electrical, and materials engineering. Medicine, plastic, materials research, and high performance electronics are just some of the many areas in which development on the nano scale are becoming a major force for technological improvement. Upon completion of their degree, our students form a unique and important human resource pool, capable of driving manufacturing and services industries towards future success.

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

Each student is required to accumulate a minimum of 146 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.

Curriculum board

Phulporn Saengbangpla	M.Sc (Machester, UK)
Pramote Dechaumphai	Ph.D. (Virginia)
Ekachai Leelarasmee	Ph.D. (California)
Asi Bunyajitradulya	Ph.D. (California)
Siriporn Damrongsakkul	Ph.D. (London)
Atiwong Suchato	Ph.D. (Massachusetts)
Patama Visuttipitukul	Ph.D. (Tokyo)
Sunhapos Chatranuwathana	Ph.D. (Michigan)
Chaodit Aswakul	Ph.D. (London)
Yan Zhao	Ph.D. (London)
Surapong Sirikulvadhana	M.S (Michigan)
Varong Pavarajarn	Ph.D. (Oregon)

Professors

Electrial Engineering
David	Banjerdpongchai,	Ph.D.(Stanford)

Chemical Engineering
Artiwan	Shotipruk,	Ph.D.(Michigan, Ann Arbor)

Associate Professors

Electrical Engineering
Songphol	Kanjanachuchai,	Ph.D.(Cambridge)
Nisachon	Tangsangiumvisai,	Ph.D.(London)

Mechanical Engineering
Asi	Bunyajitradulya,	Ph.D.(UC, Irvine)

Chemical Engineering
Deacha	Chatsiriwech,	Ph.D.(Imperial College)
Tharathon	Mongkhonsi,	Ph.D.(London)
Sarawut	Rimdusit	Ph.D.(U.S.A.)
Anongnat	Somwangthanaroj,	Ph.D.(Michigan)

Metallurgical and materials Engineering
Seksak	Asavavisitchai,	Ph.D.(Nottingham)

Assistant Professors

Electrical Engineering
Arporn	Teeramongkonrasmee,	Ph.D.(Chula)
Widhyakorn	Asdornwised,	D.Eng.(Chula)
Manop	Wongsaisuwan,	D.Eng.(T.I.T.)
Chanchana	Tangwongsan,	Ph.D.(Wisconsin)
Chanchai	Pluempitiwiriyawej,	Ph.D. (Carregie Mellan)
Thavatchai	Tayjasanant,	Ph.D.(Canada)

Mechanical Engineering
Nopdanai	Ajavakom	Ph.D.(UC,Berkeley)
Niphon	Wonsophark	D.Eng.(Chula)
Thanyarat	Singhanart,	Ph.D.(Tokyo)
Alongkorn	Pimpin,	Ph.D. (Tokyo)

Chemical Engineering
Varong	Pavarajarn,	Ph.D.(Oregon State)
Sorada	Kanokpanont,	Ph.D.(Drexel)
Kasidit	Nootong,	Ph.D.(Pennsyvania)
Soorathep	Kheawhom,	Ph.D.(Tokyo)

Metallurgical and materials Engineering
Ittipon	Diewwanit,	Sc.D.(MIT)
Patama	Visuttipitukul,	Ph.D.(Tokyo/Japan)

Industrial Engineering
Daricha	Sutivong	Ph.D.(Stanford)

Lecturer

Electrical Engineering
Chanin	Wissawinthanon	Ph.D.(USA.)
Boonchuay	Supmonchai	B.Eng.(Chula)
Supatana	Auethavekiat	Ph.D. (Tokyo)

Mechanical Engineering
Tawan	Paphapote	M.S.(Lllinolis)
Werayut	Srituravanich	Ph.D.(UCLA)

Chemical Engineering
Akawat	Sirisuk,	Ph.D.(Wisconsin)
Varun	Taepaisitphongse,	Ph.D.(UCLA)

Environmental Engineering
Achariya	Suriyawong,	Ph.D.(St.Louis)

Computer Engineering
Chate	Patanothai,	M.Sc.in EE.(Miami)

ISE Staffs
Yan	Zhao,	Ph.D.(London)
Porpin	Pungetmongkol	Ph.D.(Tokyo)
Rehan	Hussain	Ph.D.(Cambridge)

Visiting Professor
Pensri	Thongnopneua	Ph.D.
Suthiluk	Patumraj	Ph.D.(New Jersey)

Assistant Professors

Wuthichai   Wongthatsanekorn   Ph.D.(U.S.A.)

Lecturer

Niti	Yongvanich	Ph.D. (Pennsylvania)
Nuwong	Chollacoop	Ph.D.(U.S.A.)
Pahnit	Seriburi	Ph.D.
Pimporn	Uttayarat	Ph.D. (Pennsylvania)
Yupawadee	Sathirakul	Ph.D.
Wibool	Piyawattanametha	Ph.D. (Los Angeles)
Viriya	Udomphol	Ph.D.
Akarin	Phaibulpanich	Ph.D.(Michigan)
Adisorn	Tuantranont	Ph.D(Colorado)
Anurat	Wisitsoraat	Ph.D.(U.S.A.)
Oratai	Jongprateep	Ph.D.(U.S.A.)
Wuthichai	Wongthatsanekorn	Ph.D.
Benjaratg	Pupacdi	Ph.D.

Curriculum

Total number of credits requirement	147	credits
General Education	30	credits
Core Courses	111	credits
Basic Sciences	22	credits
Basic Engineering	20	credits
Compulsory Nano Engineering	33	credits
Compulsory for Major		
A. Bioengineering	18	credits
B. Advanced Material Engineering	21	credits
Approved Electives		
A. Bioengineering	18	credits
B. Advanced Material Engineering	15	credits
Free Electives	6	credits

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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	22	credits
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)
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)

Basic Engineering	20	credits
2140301 Industrial Training		2(0-6-0)
2182210 Electrical Circuit		3(3-0-6)
2182213 Electric Circuit Laboratory		1(0-3-0)
2183101 Engineering Graphics		3(2-3-4)
2183211 Engineering Mechanics		4(4-0-8)
2184303 Engineering Management		3(3-0-6)
2190101 Computer Programming		3(3-0-6)
2190151 Computer Programming Laboratory		1(0-3-0)

Compulsory for Nano Engineering	33 credits	
2141290* Statistic and Research Methodology for Nano Engineers		3(3-0-6)
2141302* Nanofabrication Technology		3(3-0-6)
2141490 Nano Seminar		4(1-0-2)
2141498 Nano-Engineering Pre-Project		1(0-2-1)
2141499 Nano-Engineering Project		3(0-6-3)
2182201 Mathematics for Nano-Engineering		3(3-0-6)
2189202* Fundamental of Materials Science and Engineering		3(3-0-6)
2182312* Signal Processing and Instrumentation		3(3-0-6)
2302106 Basic Organic Chemistry		3(3-0-6)
2302203 Organic Chemistry Laboratory		1(0-3-0)
2185222 Physical Chemistry for Nano-Engineering		3(3-0-6)
2185333 Transport Phenomena		3(3-0-6)
2189341 Materials Characterization		3(3-0-6)

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		*18 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)
2185452	Biosystems and Biotransport	3(3-0-6)
2185455*	Bioreactor	3(2-1-6)
2190456*	Introduction to Bioinformatics	3(3-0-6)

B. Advanced Material Engineering   15 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)
2189405*	Ceramics and Glasses	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)
2189581*	High Performance Metals and Alloys	3(3-0-6)
2190401*	Computation, Modelling and Problem Solving	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.

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A. BIOENGINEERING

OURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS

FIRST SEMESTER

2190101	Computer Programming	3
2190151	Computer Programming Laboratory	1
2301107	Calculus I	3
2140111	Exploring Engineering World	3
2304153	Physics for Engineers	3
2304193	Physics Laboratory for Engineers	1
5501112	Communicative English I	3
		17

SECOND SEMESTER

2141100*	Introduction to Nanotechnology	3
2183101	Engineering Graphics	3
2302105	Chemistry for Engineers	3
2302103	General Chemistry Laboratory	1
2301108	Calculus II	3
2304154	Physics and Electronics for Engineers	3
2304194	Physics and Electronics Lab for Eng	1
5501123	Communicative English II	3
		20

THIRD SEMESTER

2182201	Mathematics for Nano-Engineering	3
2182210	Electrical Circuit	3
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	3
		20

FOURTH SEMESTER

2141290*	Statist and Research Methodology for Nano-Eng	3
2182213	Electrical Circuit Laboratory	1
2303111	Biology for Engineers	3
2303112	Biology Laboratory for Engineers	1
2185222	Physical Chemistry for Nano – Eng	3
2302207*	Basic Inoraganic Chemistry	2
5501225	Technical Writing	3
xxxxxxx	General Education	3
		19

FIFTH SEMESTER

2189341	Materials Characterization	3
2182312*	Signal processing and instrumentation	3
2141355*	Introduction to Bioengineering	3
2185373	Reaction Engineering	3
2310380*	Biochemistry for Bioengineers	3
2310381*	Biochemistry Lab for Bioengineers	1
xxxxxxx	General Education	3
		19

SIXTH SEMESTER

2184303	Engineering Management	3
2141302*	Nanofabrication Technology	3
2185333	Transport Phenomena	3
2141357*	Cells Biology and Human Body	3
2189356*	Material for Biomedical Applications	3
xxxxxxx	General Education	3
		18

SUMMER SEMESTER

2140301	Industrial Training	2
		2

SEVENTH SEMESTER

2141498	Nano - Engineering Pre-Project	1
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
		16

EIGTHTH SEMESTER

2141490	Nano Seminar	1
2141499	Nano Engineering Project	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
xxxxxxx	General Education	3
		16

TOTAL CREDITS FOR GRADUATION   **147**

NANO ENGINEERING CURRICULUM
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B. ADVANCED MATERIAL ENGINEERING

OURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS

FIRST SEMESTER

				FIFTH SEMESTER	
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	3
5501112	Communicative English I	3			18
		17			

SECOND SEMESTER

SIXTH SEMESTER

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	3
2304194	Physics and Electronics Lab for Eng	1			18
5501123	Communicative English II	3			
		20			

THIRD SEMESTER

SUMMER SEMESTER

			2140301	Industrial Training	2
					2

2182201	Mathematics for Nano-Engineering	3
2182210	Electrical Circuit	3
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	3
		20

SEVENTH SEMESTER

2141498	Nano - Engineering Pre-Project	1
2189411	Mechanical Behavior of Materials	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
		19

FOURTH SEMESTER

2141290*	Statist and Research Methodology for Nano-Eng	3
2182213	Electrical Circuit Laboratory	1
2303111	Biology for Engineers	3
2303112	Biology Laboratory for Engineers	1
2185222	Physical Chemistry for Nano – Eng	3
5501225	Technical Writing	3
xxxxxxx	General Education	3
		17

EIGTHTH SEMESTER

2141490	Nano Seminar	1
2141499	Nano Engineering Project	3
2189450	Materials Design and Selection	3
xxxxxxx	Approved Electives	3
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		16

TOTAL CREDITS FOR GRADUATION   **147**

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 3(3-0-6)
Skills
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 Sciences
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.

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

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

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

Basic Engineering
2140301 Industrial Training 2(0-6-0)
Condition: PRER 2301108 Calculus II
Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

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)
Condition: PRER 2301108 Calculus II
Electronic instruments; Multimeter; oscilloscope; DC circuit; Voltage regulators; Filter circuit; Transistor amplifier circuit; Op-amp circuits; Digital circuits; DC motor.

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.

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　1(0-3-0)
Laboratory**
Computer programming in Engineering; reviews of computer programming concepts; hands-on experience on computer programming using contemporary engineering tools.

Compulsory for Nano Engineering
**2141290*　Statistic and Research　3(3-0-6)
Methodology for Nano Engineers**
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.

2141490　Nano Seminar　4(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.

**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,

Indicial 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, Indicial 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 BraKet, Eigenvalue, Eigenfunction, Expectation Values, Overview of Nanotechnology, Applications to Scanning Tunneling Microscope Image.

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

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.

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

Compulsory for Major
A. Biomedical Nanotechnology

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   **3(3-0-6)**
         Applications
         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   **1(0-3-0)**
         Bioengineers

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

B. Nano Materials Science

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

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   **3(3-0-6)**
         Engineering
         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   **3(3-0-6)**
         Kinetics
         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 .Biomedical Nanotechnology

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

Importance of nanotechnology in enhancing pharmaceutical technology; Fundamental pharmaco-kinetics 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 matrics (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 3(3-0-6)
  Imaging

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 3(3-0-6)
  Rehabilitation Technology

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, hearings 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 3(3-0-6)
  Regenerative Medicine
  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 1(1-0-2)
  Bioengineering 1

Advance topics in the field of bioengineering

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

Advance topics in the field of bioengineering

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

Interesting topics in the field of bioengineering.

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

Interesting topics in the field of bioengineering.

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

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 3(3-0-6)
  Mechanical Systems

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. Nano Materials Science

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 matrics (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 1(1-0-2)
 Material engineering I

Advance topics in the field of Advanced Material engineering

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

Advance topics in the field of Advanced Material engineering.

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

Interesting topics in the field of Advanced Material engineering.

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

Interesting topics in the field of Advanced Material engineering.

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

Interesting topics in the field of Advanced Material engineering.

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

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 3(3-0-6)
 Applications
 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　　　　3(3-0-6)
**　　　　　Problem Solving**

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.