

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 - microscopically 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)
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Associate Professors

Electrical Engineering

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

Mechanical Engineering

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

Artiwan Shotipruk,	Ph.D.(Michigan, Ann Arbor)
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)
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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 Pluempitiwiriyaewej,	Ph.D. (Carregie Mellan)
Thavatchai Tayjasant,	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.(Pennsylvania)
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.(Illinois)
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	146	credits
General Education	30	credits
Core Courses	110	credits
Basic Sciences	22	credits
Basic Engineering	30	credits
Compulsory	34	credits
Approved Electives	24	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)
2189336 Materials in Daily Life	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	110	credits
<u>Basic Mathematics and Sciences</u>	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)
<u>Basic Engineering</u>	30	credits
2140301 Industrial Training	2	(0-6-0)
2182201 Mathematics for Nano-Engineers	3	(3-0-6)
2182203 Probability and Statistics for Engineers	3	(3-0-6)
2183101 Engineering Graphics	3	(2-3-4)
2184303 Engineering Management	3	(3-0-6)
2185222 Physical Chemistry for Nano-Engineers	3	(3-0-6)
2185320 Inorganic Chemistry for Nano-Engineers	3	(3-0-6)
2189101 Engineering Materials	3	(3-0-6)
2189201 Introduction to Materials Science and Engineers	3	(3-0-6)
2190101 Computer Programming	3	(3-0-6)
2190151 Computer Programming Laboratory	1	(0-3-0)
<u>Compulsory</u>	34	credits
2141490 Nano Seminar	4	(1-0-2)
2141491 Research Methodology	2	(2-0-4)
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 Electrical Circuit Laboratory	1	(0-3-0)
2182280 Semiconductor Devices I	3	(3-0-6)
2182311 Measurement and Instrumentation	3	(3-0-6)
2183211 Engineering Mechanics	4	(4-0-8)
2185220 Basic Organic Chemistry	3	(3-0-6)
2185221 Organic Chemistry Laboratory	1	(0-3-0)
2185322 Thermodynamics for Nano-Engineers	3	(3-0-6)
2185333 Transport Phenomena	3	(3-0-6)
2189341 Materials Characterization	3	(3-0-6)

Approved Electives

Approved Elective Level 1

Select 12 Credits from 2 fields in the following list.

Fields Nanoelectronics

2182440	Introduction to Nanoelectronics	3 (3-0-6)
2183411	Micro and Nanofabrication Technology	3 (3-0-6)

Fields Nano Chemistry

2185324	Molecular Chemistry	3 (3-0-6)
2185373	Reaction Engineering	3 (3-0-6)

Fields Biomedical Nanotechnology

2182441	Biomedical Electronics	3 (3-0-6)
2141350	Biological Interaction with Materials	3 (3-0-6)

Fields Nano Materials Science

2141400	Principles of Nanostructured Materials	3 (3-0-6)
2189301	Bonding, Crystallography and Defects	3 (3-0-6)

Approved Elective Level 2

Select 12 credits from any courses in the following list or from courses in Approved elective level I.

2141331	Quantum Mechanics for Engineers	3 (3-0-6)
2141347	Introduction to Pharmaceutical Nanotechnology	3 (3-0-6)
2141451	Bionanotechnology	3 (3-0-6)
2141474	Introduction to Lab-on-a-Chip	3 (3-0-6)
2141511	Special Topics in Nano Eng I	3 (3-0-6)
2141512	Special Topics in Nano Eng II	3 (3-0-6)
2182330	Linear Control Systems	3 (3-0-6)
2182443	Introduction to VLSI Technology	3 (3-0-6)
2182480	Semiconductor Devices II	3 (3-0-6)
2182580	Optoelectronics	3 (3-0-6)
2183412	Micro and Nano-Electro Mechanical Systems	3 (3-0-6)
2183431	Mechanical Vibrations	3 (3-0-6)
2185323	Intermediate Organic Chemistry	3 (3-0-6)
2185452	Biosystems and Biotransport	3 (3-0-6)
2185479	Nanopolymer Engineering	3 (3-0-6)
2189411	Mechanical Behavior of Materials	3 (3-0-6)
2189417	Composite Materials	3 (3-0-6)
2189450	Materials Design and Selection	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)**

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER			FIFTH SEMESTER		
2190101	Computer Programming	3	2182311	Measurement and Instrumentation	3
2190151	Computer Programming Laboratory	1	2185320	Inorganic Chemistry for Nano-Eng	3
2301107	Calculus I	3	2189341	Materials Characterization	3
2302103	General Chemistry Laboratory	1	2189336	Materials in Daily Life	3
2302105	Chemistry for Engineers	3	xxxxxxx	Approved Electives	<u>6</u>
2304153	Physics for Engineers	3			18
2304193	Physics Lab. For Engineers	1	SIXTH SEMESTER		
5501112*	Communicative English I	<u>3</u>	2184303	Engineering Management	3
		18	2185322	Thermodynamics for Nano-Eng	3
SECOND SEMESTER			2185333	Transport Phenomena	3
2140111	Exploring Engineering World	3	xxxxxxx	Approved Electives	6
2183101	Engineering Graphics	3	xxxxxxx	General Education	<u>3</u>
2189101	Engineering Materials	3			18
2301108	Calculus II	3	SUMMER SEMESTER		
2304154	Physics and Electronics for Eng	3	2140301	Industrial Training	<u>2</u>
2304194	Physics and Electronics Lab. for Eng	1			2
5501123	Communicative English II	<u>3</u>	SEVENTH SEMESTER		
		19	2141491	Research Methodology	2
THIRD SEMESTER			2141498	Nano-Engineering Pre-Project	1
2182201	Mathematics for Nano-Engineering	3	xxxxxxx	General Education	3
2182210	Electrical Circuit	3	xxxxxxx	Approved Electives	9
2183211	Engineering Mechanics	4	xxxxxxx	Free Elective	<u>3</u>
2189201	Introduction to Material Science and Eng	3			18
2185220	Basic Organic Chemistry	3	EIGHTH SEMESTER		
2185221	Organic Chemistry Laboratory	1	2141490	Nano Seminar	1
5501214	Communication and Presentations Skills	<u>3</u>	2141499	Nano Engineering Project	3
		20	xxxxxxx	Approve Electives	3
FOURTH SEMESTER			xxxxxxx	General Education	6
2182203	Probability and Statistics for Engineers	3	xxxxxxx	Free Elective	<u>3</u>
2182213	Electrical Circuit Laboratory	1			16
2182280	Semiconductor Devices I	3	TOTAL CREDITS FOR GRADUATION		
2303111	Biology for Engineers	3			<u>146</u>
2303112	Biology Laboratory for Engineers	1			
2185222	Physical Chemistry for Nano-Eng	3			
5501225	Technical Writing	<u>3</u>			
		17			

**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.

2189336 Materials in Daily Life 3 (3-0-6)

Different aspects of materials as found in daily life, in various occupations and in various applications; environmentally friendly materials; full utilization of materials in both efficient sense and artistic sense; topics related to materials for design.

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 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 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.

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.

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

Condition: PRER 2301108 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 Nottation, 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 Maniquilation 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.

2182203 Probability and Statistics for Engineers **3 (3-0-6)**

Condition: PRER 2301108 Calculus II

Engineering basis in statistics and probability; discrete and continuous probability distribution; joint probability distribution; parameter estimation: estimator, bias, consistency; point estimation; interval estimation; engineering applications in measurement and uncertainty, linear regression, introduction to random process; integration of statistics in engineering applications; case studies.

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.

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.

2185320 Inorganic Chemistry for Nano-Engineering **3 (3-0-6)**

Atomic structure and periodicity; molecular geometry and symmetry; introduction to molecular orbital theory; reaction with electron transfer; inorganic solids.

2189101 Engineering Materials **3 (3-0-6)**

Important engineering materials: metals, plastics, asphalt, wood and concrete; phase diagram and its interpretation; testing and meaning of various properties; macroscopic and microscopic structures which are correlating with properties of the engineering materials; production process of products from engineering materials.

2189201 Introduction to Materials Science and Engineering **3 (3-0-6)**

Atomic structures and bonding in solids; crystallography; phase, surface and interface; defects and dislocations; diffusion in solids; phase equilibrium diagrams; mechanical properties; relationship between micro-and nano-structures and properties of engineering

materials; classes of engineering materials; production and processing of engineering materials.

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

2141490 Nano Seminar **1 (1-0-2)**

Seminar on interesting topics related to nano-engineering.

2141491 Research Methodology **2 (2-0-4)**

Research Formulation, research objectives, basic procedure for doing research. Statistical method for research, analysis of data and its implication.

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.

2182280 Semiconductor Devices I **3 (3-0-6)**

Crystal properties and growth of semiconductors; atoms and electrons; energy band and charge carriers in semiconductors; excess carriers in semiconductors; junctions; field-effect transistors; bipolar junction transistors; optoelectronic devices; power devices.

2182311 Measurement 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 discrete systems.

2183211 Engineering Mechanics 4 (4-0-8)

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, bending moment diagram, torsion, buckling of columns, Mohr's circle.

2185220 Basic Organic Chemistry 3 (3-0-6)

CONDITION: PRER 2302105 Chemistry for Engineering

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

2185221 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.

2185322 Thermodynamics for Nano-Engineering**3 (3-0-6)**

Heat, work, internal energy, enthalpy, and the first law of thermodynamics; entropy and the second law of thermodynamics; the third laws of thermodynamics; application to flow processes and to non-reacting mixtures; chemical equilibrium; phase equilibria; ideal and real solution.

**Transport Phenomena Material Characterization
Approved Elective Level 1****Fields Nanoelectronics****2189341 Materials Characterization****MAT CHARN****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

2182440 Introduction to Nanoelectronics**INTRO NANOelec****3 (3-0-6)**

CONDITION: PRER 2182280 Semiconductor Devices I*

Introduction to nanotechnology; nanoscale fabrication; nanoscale characterizations; 1D quantum structure; 0D quantum structure; single electron devices; carbon nanotubes; molecular electronics; DNA chips; quantum dot cellular automata; MEMS/ NEMS; spintronics.

2183411 Micro and Nano Fabrication Technology**MIC/NANO FAB TECH****3 (3-0-6)**

Crystal growth: vapor phase epitaxy (VPE), liquid phase epitaxy (LPE), molecular beam epitaxy (MBE), solid-state diffusion, metal-organic chemical vapour deposition (MOCVD), vacuum technology; device fabrication: inversion layer in MOS structure, thermal oxidation, ion implantation, metallization, optical lithography, electron beam lithography, pattern transfer, wet/dry etching, reactive ion etching.

Fields Nano Chemistry**2185324 Molecular Chemistry****MOL CHEM****3 (3-0-6)**

Fundamental concepts of molecular chemistry and its applications in both organic synthesis and catalysis.

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

Fundamentals of reaction engineering; reaction rate laws; kinetics; mechanisms of homogeneous and heterogeneous reactions; analysis of reaction rate data; diffusion limitations; design of industrial reactors.

Fields Biomedical Nanotechnology**2182441 Biomedical Electronics****BIOMED ELEC****3 (3-0-6)**

CONDITION: Consent of Faculty

Electrical signals in human body; action potential in cells; electrodes; amplifiers; transducers; electronic monitoring systems; ECG, EEG, EMG; blood pressure and blood flow measurement; catheterization electrical hazards and prevention; medical instrumentation; computer in medicine.

2141350 Biological Interaction with Materials**BIOL INACT MAT****3 (3-0-6)**

Basic biological systems that interact with the biomaterials and the range of materials currently used for biomedical applications; appropriate analytical techniques pertinent to biomaterial research and evaluation; selected important medical fields in which biomaterials play a critical role.

Fields Nano Materials Science**2141400 Principles of Nanostructured material****PRIN NANOSTRUC MAT****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 nanomaterial; diffusional and diffusionless transformations and kinetics.

2189301 Bonding, Crystallography and Defects**BONDG CRYST DEFEC****3 (3-0-6)**

Atomic structure, hybridization, molecular orbital theory; covalency, ionicity, electronegativity; band structures of semiconductors; transition metals and ferromagnetism; crystal structures, group and symmetry and diffractions; structural features of materials; point defects, dislocations, and surfaces; pure elements, solid solutions, compounds and phase diagrams.

Approved Elective Level 2**2141331 Quantum Mechanics for Engineers****QUANT MECH ENG****3 (3-0-6)**

Dual nature of waves and particles; the postulates of quantum mechanics; concepts of function spaces and Hermitian operators; superposition principles and compatible observables; Schrodinger equation and

problems in one dimension; hydrogen atom; angular momentum; wavefunctions of electrons in confined potentials.

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

Importance of nanotechnology in enhancing pharmaceutical technology; fundamental pharmacokinetics for engineers; reviews of the types and characteristics of physic-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.

2141451 Bionanotechnology 3(3-0-6)

Nanosensors and nanodevices for clinical diagnostics; nanostructures for drug delivery; nanoarrays; use of nanoanalytical devices and systems; methods and techniques for modification or functionalization of nanoparticles and nanostructures with biological molecules; potential use of DNA and other biomolecules for computing and ultra high-density data storage.

2141474 Introduction to Lab-on-a-Chip
INTRO LABCHIP 3 (3-0-6)

Interesting topics in the field of nano-engineering.

2141451 Special Topics in Nano Engineering I
SPEC NANO ENG I 3 (3-0-6)

Interesting topics in the field of nano-engineering.

2141512 Special Topics in Nano Engineering II
SPEC NANO ENG II 3 (3-0-6)

Interesting topics in the field of nano-engineering.

2182330 Linear Control Systems
LIN CTRL SYS 3 (3-0-6)

*CONDITION: PRER 2182210**

Open-loop and closed-loop control systems; mathematical models of physical systems; linearization; block diagrams; signal flow graphs; basic control actions and compensations; time-domain responses; Routh-Hurwitz stability test; control system design by the root locus method; Bode and Nyquist plots; Nyquist stability criterion; Nichols charts; control system design by frequency response method.

2182443 Introduction to VLSI Technology
INTRO VLSI TECH 3 (3-0-6)

Fundamentals of digital and analogue circuits.

2182480 Semiconductor Devices II
SEMICOD DEVI II 3 (3-0-6)

*CONDITION: PRER 2182280**

Semiconductor Devices I

Review of physics and properties of semiconductors; compound semiconductor; P-N junction; metal-semiconductor junctions; heterojunctions; MESFET; heterojunction transistors: HEMT and HBT; microwave devices; high speed photonic devices and integrated circuits.

2182580 Optoelectronics
OPTOELECTRONECS 3 (3-0-6)

CONDITION: PRER 2182280

Physics of optical radiation; interaction between optical radiation and matter; principles and applications of optoelectronic devices: sources, detectors as well as other optical materials, devices, components and equipment.

2183412 Micro and Nano-Electro Mechanical Systems
MEMS/NEMS 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; application of MEMs: pressure sensors, accelerometer; micromotors; micropumps and microvalves; thermal sensors and actuators; micromirror.

2183431 Mechanical Vibrations
MECH VIBRATIONS 3 (3-0-6)

Analysis of system with single and multi-degree of freedom; torsional vibration; free and forced vibration; determination of natural frequencies of structures; discrete system; Modal analysis; methods and techniques to reduce and control vibration; Lagrange's equations.

2185323 Intermediate Organic Chemistry
ITMD ORG CHEM 3 (3-0-6)

Basic concept of chemistry, structure, nomenclature and identification of organic compounds: saturated hydrocarbons and petroleum, unsaturated hydrocarbons; free-radical addition and polymerization; aromatic hydrocarbons and electrophilic aromatic substitution; organic halides; alcohols; phenols and ethers; aldehydes and ketones; carboxylic acid and derivatives; fats, oils, waxes, soaps and detergents; stereoisomerism and optical activity; sugars and carbohydrates; amines and diazonium compounds; amino acids and proteins.

2185452 Biosystems and Biotransport
BIOSYS/BIOTRANS 3 (3-0-6)

Definitions and basic concepts; crystalline and glassy polymer; molecular architecture; conformation and morphology; polymer synthesis; transition phenomena; mechanical properties affected by the 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.

2185479 Nanopolymer Engineering 3 (3-0-6)

Definitions and basic concepts; crystalline and glassy polymer; molecular architecture; conformation and morphology; polymer synthesis; transition phenomena; mechanical properties affected by the 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.

2189411 Mechanical Behavior of Materials
MECH BEHAV MAT 3 (3-0-6)

Elastic behavior; 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.

2189417 Composite Materials

COMPOSITE MAT 3 (3-0-6)

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

2189450 Materials Design and Selection

MAT DSGN SEL 3 (3-0-6)

Basic materials; concept of materials selection; steps in materials design; case studies.