Descriptions of Courses

NT511 NanoScience
As a fundamental required course, various scientific aspects of Nano Science and Technology will be treated. Starting from quantum mechanical natures nano-structures such as quantum mechanics, quantum chemistry, various subjects related to the simulation, modeling, analyses of nanomaterials and nanobiotechs will also be discussed.

NT512 NanoTechnology
As a second required source, various technical aspects of Nano Science and Technology will be presented. Topics includes nanorithography, self assembly, ALD and thin film manufacture processes, nano powder and various devices application. Electrical energy and chemical energy in nanostructures are also treated.

PH503 Quantum Mechanics Ⅰ
This course introduces the mathematical foundation of quantum mechanics to the first year physics graduate students. Topics include: Hilbert space, Measurement theory, Theory of rotation and Angular momentum, Group theory and application to quantum mechanics, Wigner Eckart theorem, Clebsch Gordon coefficients, Stationary perturbation, Time dependent perturbation, Applications to atoms, molecules and solids.
Topical Prerequisites: One year of undergraduate Quantum Mechanics, Mathematical Physics, Mechanics, Electromagnetism.

PH504 Quantum Mechanics Ⅱ
This course is designed to help the first year physics graduate students understand complicated phenomena of scattering and to give an introduction to the second quantization and Dirac equation for future use in solid state physics and particle physics. Topics include: Scattering, Nonrelativistic Second Quantization, Fermion Systems and Boson Systems, Dirac Equation.
Prerequisites: PH503 Quantum Mechanics I.

PH611 Advanced Solid State Physics I
This course is intended to provide graduate students in physics, chemistry, electrical engineering, and materials science with a graduate-level understanding of topics in solid state physics. Topics include: Brillouin zone, Crystal symmetry, Phonons, Electron energy band theory, Electron-electron and electron-phonon interactions, Electron dynamics, and Transport properties.
Prerequisites: PH503 and PH504

PH612 Advanced Solid State Physics II
This course follows the course Advanced Solid State Physics I, and is intended to provide graduate students in physics, chemistry, electrical engineering, and materials science with a graduate-level understanding of advanced topics in solid state physics. Topics include: Optical properties, Elementary excitations, Electron correlations, Many body effects, Green's functions, Density functional theory, Magnetism, Superconductivity, and Nonlinear phenomena.
Prerequisites: PH503 and PH504.

PH711 Physics of Magnetism
This course introduces from the physics of macroscopic magnetic properties of magnetic materials to the spintronics that handles individual spins quantum mechanically. Topics include the Origin of magnetism, Magnetic domain, Magnetic anisotropy, Magnetoresistance and spin tunneling.

PH726 Semiconductor Optics
This course introduces optical processes occurring at semiconductor band edges, and their applications to various opto-electronic devices. Topics include: Band edge absorption, Non-linear absorption, Semiconductor quantum wells/dots, Semiconductor lasers , Photonic crystals and Photonic devices.
Prerequisite: Solid State Physics and Quantum Mechanics.

BS465 NanoBio Technology
This course deals with how the basic principles of nanotechnology can be integrated into biotechnology and what industrial fields will be created by this consequence in the future.

BS524 Advanced Molecular Biology
This course is designed to give students a basic understanding and history of molecular biology. Topics include: structure and function of nucleic acids, enzymes involved in DNA replication, in vivo DNA replication, transcription and translation in general.

BS583 Structural Biology
This lecture eleaborates on how biological functions of organisms at the molecular level operate, by understanding the 3-D structure of large biomolecules such as proteins.

CH502 Quantum Chemistry I
The purpose of this course is to give graduate students in Chemistry the ability to understand electronic structure and spectroscpoic properties of atoms and molecules by means of theoretical techniques, such as ab initio and semiempirical methods. Topics include : Hartree-Fock Approximation, configuration interaction, ab initio and semiempirical methods.
Prerequisite Course : CH315
Prerequisites by topic : Matrix algebra, Hypergeometric functions, Fundamentals of classical mechanics, and Group theory.

CH604 Quantum Chemistry II
This course presents molecular spectroscopy and modern quantum chemistry with main emphases on the understanding of modern electronic structure calculations.
Topics include : Brief review of rudimentary Quantum Mechanics, Atomic spectra, Rovibronic spectra of diatomic molecules, Rovibronic spectra of polyatomic molecules, Magnetic resonance spectroscopy, Modern spectroscopy, Ab initio MO calculations and Semi-empirical MO calculations.

CH607 Surface Chemistry
This course is designed to give high-level understanding to the Chemistry of solids, mainly metal and gas-solid interface structures. Thermodynamics and dynamics of the solid surface are discussed with a brief introduction to solid state dynamics. The main area of study is the absorption and deabsorption of gas molecules on metal surfaces and implications of these phenomena to the theory of catalytic behavior.
Topic include : Principle of the surface analysis methods such as Auger, XPS, LEED, SEXAFS, Chemisorption on surfaces, and Catalytic reactions on surfaces.

MAE662 Design of Precision Actuation System
This course is designed for graduate students. In the beginning, Design principles are introduced. Next, several structure design techniques such as kinematic design, flexture mechanism design, guide mechanism design, etc. are studied. Then error analysis/compensation and uncertainty analysis are dealt with. In this course, every student proposes a term project and the result of the project is estimated by presentation at the end of the semester.

MAE810 Special Topics in Thermal & Fluid Engineering
This lecture is designed to deal with the selected theory and application in thermal and fluid engineering part. The specific topics will be announced before the semester begins.

BiS471 Bio-Inspired Systems
This course provides scientific foundation and engineering platform for the bio-inspired systems, where bio-inspired sensors, actuators and controllers are linked together to achieve new or advanced functions. Topics include the physical and functional analogy of biological and engineering systems; the principles and methods of sensory, locomotive and neural functions; the quantitative analysis and engineering design of bio-inspired systems. Required are the technical reporting and the oral presentation of term projects on bio-inspired systems for applications to the areas of information and communication, electronics and appliance, automotive and aerospace, biomedical diagnosis, environmental monitoring and/or industrial instrumentation.

BiS472 Micro Heat & Mass Transport
This course discusses analysis tool and phenomenon of heat and mass transfer in microregion, and provides micro heat transfer through conduction, convection and radiation. Also, basic principles and applications of material diffusion and reaction are discussed.

BiS522 Genomics and Proteomics
This course describes the determination of the nucleotide sequence as well as many further analyses used to discover functional and structural gene information on all the genes of an organism. This course deals with the basic genetic analysis on a genome-wide scale.

BiS571 BioElectroMechanics
This course provides electromechanics for understanding and analysis of biomechatronic systems. An analogy between mechanical systems and electrical systems, modeling of electromechanical systems, and working principles of biomedical, diagnostic, surgery and therapeutic equipments are discussed.

BiS572 Microtransducers and Laboratory
This course discusses working principles, materials, configurations and performance specifications of microtransducers based on MEMS technology. On these basis, experiments using mechanical, electrical, optical, thermofluidic and biochemical microtransducers, are provided.

BiS623 Bioelectronic Devices
This course covers advanced topics in the design and industrial application of bioelectronic devices such as biosensor and biochip. The fundamental principles in these areas have emphasized to understand the biological recognition mechanism of enzyme, antibody, microorganism, animal cell, and DNA.

BiS671 Nanomaterial Process and Behavior
This course treats the topics of properties, behaviors and controls of nanoparticles, and introduces machining processes of nanomaterials. Stability, reproducibility and reliability of nanoparticles and nanomaterials are discussed.

BiS672 Nano Electro Mechanical Systems
This course discusses physical phenomena and engineering problems arising from nanometric area. Topics included are analysis of the nano physical principles and design of the working principles, nano materials and its fabrication processes, and nano testing and chacracterization techniques. This course also provides basic knowledge of the Nano Electro Mechanical Systems (NEMS). Term projects and presentation are required.

BiS771 Nanobiotechnology
This course discusses microenergy conversion and transfer as well as the property and behavior of micromaterials based on mechanical, material, physical, chemical and biological analysis of biomedia and their reactions. Topic included are nanoscale phenomena in cellular physiology / metabolism, micro / Nano fabrication processes with unusual materials, microfabricated tools for neuroscience, biological motors and nanobiochips.

BiS772 Nano/Micro-Machining Process Laboratory
This course discusses equipments and processes of nano / micro fabrication. Also, practices of nano / micro fabrication are provided. Term projects and presentation based on design, fabrication and test of nano / micro devices are required.

CBE455 Nanochemical Technology
This course deals with theories and experimental methods for predicting the nanostructure-macroscopic property relations under equilibrium and nonequilibrium conditions. Nanofabrication methods considered in this course cover the conventional top-down lithographic techniques and the self-assembling bottom-up approaches. The building blocks for nanostructures include surfactant micelles, block copolymers, inorganic particles, liquid crystals, polymer latexes and biomolecules. Interactions between building blocks that govern the phase behavior of nanostructures will be discussed.

CBE512 Introduction to catalysis engineering)
This course discusses catalytic activity, selectivity and kinetics of catalyst. This course also discusses synthesis of catalysts.

CBE522 Introduction to interfacial engineering
The aim of this course is to introduce and motivate the research of surface and nano-surface science and chemistry for first year graduate students. The basic structure consists of three parts ; surface structure and energy, molecular alignment at surface, and electrical and dispersive interaction at interface.Covered at this course were the concepts

of surface energy, curvature effect, quantum-size effect, molecular interaction, surface force measurement, surfactant, detergency, micelles and aggregation, adsorption in solution, contact angle, wetting, monolayer, organic thin film, LB film, hydrogels and liquid crystals, emulsion and dispersions.

CBE525 Molecular Electronics
This course covers molecular electronic in organic materials, molecular methodologies, biooptoelectronics and molecular electronic logic and archetecture. Detailed topics includes molecular scale electronics in nano-science, Foundations and theories of molecular electronics, properties and ordering of materials, piezoelectric and pyroelectric materials, molecular magnets, molecular nonlinear optics, photochromism, conducting polymers, charge transfer complex, OLED, liquid crystals and devices, self-assembly, Langmuir-Blodgett films, organic molecular beam epitaxy, molecules at surface, biological membrane, biosensors, biomolecular optoelectronicsmolecular imaging, molecular electronic logic and architecture.

CBE612 Design of catalysis
The procedures of catalyst selection for specific chemical reactions include theoretical utilization of potential information and experimental evaluation. Design parameters for both homogeneous and heterogeneous catalysis are to be discussed. The concept of catalyst design, activity patterns of active components, selection of secondary components and supports, catalyst preparation and experimental testing are to be discussed. Some examples of catalyst design are to be introduced for important chemical reactions.

CBE632 Colloids and Surface Chemistry
The aim of this course is to establish the fundamental concepts on the colloid and biocolloid for industrial and pharmaceutical applications. FollowingIntroduction to interfacial engineering, this course is designed to understand in depth and art-of-state knowledge of electrical phenomena, surface modification and adhesion, stabilization of emulsion, foam, and particle dispersion , microcapsules and their industrial applications. Special attentions are paid to pharmaceutical and biomedical applications throughout the topics including sophisticated drug delivery systems.

CBE682 Organic Nano-structured Materials
This lecture includes: non-crystal, crystals, liquid crystals, imperfections in ordered media, and finally nano-structure. Because the properties of nanomateri인 are structure-sensitive, numerous associations in this class will be made to establish structure-property relations for advanced organic materials using very useful experimental techniques, in particular, diffraction and microscopy. Applications to IT and BT devices using nanostrctured materials are also discussed.

CBE712 Surface Phenomena
The fundamental principles and the application of surface science are lectured to understand the phenomena at the level of molecules of the surface of catalyst, polymer and inorganic materials. The most widely used surface science instruments such as XPS, AUGER, ISS, UPS, SIMS, LEED, ELLS, SEXAFS, RHEED, work function measurement, TDS will be discussed to understand the principles, operating components and the application to the real samples.

NQE488 Special Topics in Nuclear and Quantum Engineering I
This course covers special and important areas of nuclear and quantum engineering that are not covered or emphasized by other courses. The content is variable, as chosen by the instructor.

NQE513 Neutron and Quantum Particle Transport Theory and Computation
This course is designed to cover the particle transport solution theory, numerical algorithms, and computational methods for continuous, one-group, multi-group neutron and radiation transport phenomena. Major topics are: singular eigenfunction expansion, Green's function, spherical harmonics, discrete ordinates, integral transport, even-parity transport, method of characteristics, Boltzmann-Fokker-Planck transport methods for various quantum particle (neutrons, photons, electrons, positrons, protons, etc) transport phenomena, applied to the design of various nuclear reactors, radiation shielding facilities, analysis of radiation and energy deposition profiles in systems such as nuclear fusion reactor, accelerator, nuclear bio-medical equipment, semiconductor electronics system, and nuclear imaging problems such as nuclear prospecting, nuclear assay, computed tomography.

NQE524 Simulation of Nuclear and Quantum System
This course provides students with an understanding of numerical analysis, artificial intelligence and simulation methodologies which can be applied in nuclear and quantum engineering. To solve the partial differential equations, finite difference method, finite element method, Monte Carlo method and so on are discussed. In the artificial intelligence section, the course covers expert system, neural network, fuzzy theory, and other artificial intelligence language. Students can understand about uncertainty problem and sensitivity study in computer codes.

NQE526 Quantum and Micro Energy Transport
This course provides students with an understanding of quantum and micro energy transport phenomena. This course covers the concept of energy carriers - phonon, electron and photon, and analytical methods based on molecular dynamics simulation. This course will make discussions on applied areas such as thermoelectric power generation and cooling, heat conduction and phase change in thin film, and micro measurement techniques.

NQE571 NMR Engineering
This course introduces the basic theory of nuclear magnetic resonance (NMR) phenomena, NMR imaging techniques, NMR spectroscopy techniques and related equipments. In addition to the basic principles of NMR techniques, some examples of NMR applications in biomedical research, nanoporous materials and NMR quantum computations are discussed and some basic NMR experiments related to lectures are performed.

NQE572 Neutron Optics
This course introduces the theory of neutron optical phenomena and the theory of neutron scattering for condensed matter research. The contents include the elements of quantum mechanics, the fundamental properties of neutron, the neutron nuclear scattering and magnetic scattering, a brief introduction to the neutron optical device and neutron scattering instruments. A few practical examples of neutron scattering experiments are also discussed.

MS523 Electron Microscopy and Experiment
This course covers topics such as electron guns, electron lenses, optics, reciprocal lattice / Ewald sphere construction, structures factor, kinematical, dynamical, indexing, stereographic analysis, inelastic scattering and Kikuchi electron diffraction, origins of contrast, perfect crystals, imperfect crystals, artifacts, amplitude vs phase contrast, identification of defects.

MS536 Thin Film Processing
This course is planned to give graduate students in Materials Science and Engineering an understanding of the process and analysis technologies of thin films

MS654 Surface Science
This course treats physical and chemical properties of surfaces and interfaces of material and interactions of electrons and photons with material surfaces, and describes modern scientific tools to obtain information about composition, structure and chemistry of surfaces on a microscale, such as, AES, XPS, FTIR, LEED, RBS, SIMS, EPMA, Raman spectroscopy, etc.

MS670 Sol-Gel Nano Materials and Process
In this course, fundamentals of sol-gel process and fabrication of ceramics and glasses by sol-gel process are studied. Also, synthesis and application of nano materials such as nano composites, nano hybrids, nano structured materials, mesoporous materials, and biomaterials prepares by sol-gel nano process are introduced

MS671 First-principles Modeling of Materials
Fundamental concepts of ab initio quantum chemical methods and density functional theory (DFT) methods are introduced. The strength and weakness of ab initio and density functional theory methods are discussed in light of accuracy and computational costs. In addition, we will apply first-principles simulations to design and understand nano materials and nano processes (term projects). Examples include carbon nanotubes, organic nanowires on silicon, hydrogen storage materials, fuel cells, atomic layer deposition techniques, and chemical vapor deposition processes.

MS672 Special Topics on Nano Materials Technology
A group project will be a major component of this course. The purpose of the project is to bring together students of the similar interest to explore exciting areas of nanotechnology and to practice generating new research

ideas. In the beginning of the course, each student will review the fifteen areas of nanotechnology distributed at the beginning of the class. They will select the 3-5 topics that they find most interesting. The instructor will then match students with common interests into groups. Once the groups are formed, they will work together to create their own research proposal. The proposal will either be written or presented to the class, depending on student interests and the number of students who take the class. The instructor is willing to meet with the teams during the quarter to help them find the background literature that is needed for their project and to help them develop their research ideas. Some class time will be used for this purpose.

MS685 Physics of Magnetism and Magnetic Materials
In this course, physics of magnetism and application of magnetism will be the two major topics to be covered. Basic concepts of magnetism, magnetic units, origin of magnetism in materials and magnetization processes of magnetic materials under DC and AC magnetic fields will be lectured on. Also magnetic anisotropy, magnetostriction and magnetic domains will be intensively covered. Lastly, engineering applications of magnetic materials in electromagnetic equipment, permanent magnets and external magnetic recording devices for computer application engineering will be discussed in the course.

EE461 Semiconductor Devices
In this course, we study in depth how the basic semiconductor devices operate. Various semiconductor devices are examined including a pn junction diode, a bipolar junction transistor (BJT), and two-field effect transistors (MOSFET, JFET). This course will also cover non-ideal effects in the real semiconductor devices.

EE561 Introduction to VLSI Devices
This course covers fundamental VLSI device physics for graduate students. After a brief review of basic quantum mechanics and semiconductor processes, the lecturer will cover basic principles of operation in semiconductor devices including PN junction, MOS Capacitor, MOSFET and bipolar transistors with a strong emphasis on deep submicron secondary effects of MOSFET and bipolar transistors for extensive understanding of advanced device engineering. (prerequisite: EE461)

EE661 Solid State Physics
This course is for graduate students. The course will cover basic concepts in solid state physics including solid structures, symmetry, reciprocal space, lattice dynamics, electrons in metals, semiconductors, dielectric and magnetic properties of both bulk solids and nano-structure.

EE663 High Frequency Electronic Devices
This course aims to give an understanding of the fundamental principles and technological developments in high-frequency electronic devices for microwave and high-speed digital / analog electronic systems and applications. (Prerequisite: EE461)

EE762 Advanced MOS Device Physics
This course will cover advanced device physics of MOSFETs and their ultimate scaling. Recent trends such as a new device structure and a new material will be introduced, and various types of memory devices as an example of detailed applications are also covered. Through a depth of study in quantum effects, reliability issues, and modeling, this course can provide core knowledge of next device technologies and a chance to explore new applications.
(Prerequisite: EE461, EE561)

NT591 Special Topics of NanoTechnology Ⅰ
To give a lecture on topics related to Nanotechnology that is not listed in majors and electives.

NT592 Special Topics of NanoTechnology Ⅱ
To give a lecture on topics related to Nanotechnology that is not listed in majors and electives.

NT966 M. S. Seminar
To give students chances to attend seminars on current researches in the fields of nanoscience/technology and other disciplines.

NT986 Ph.D Seminar

To give students chances to attend seminars on current researches in the fields of nanoscience/technology and other disciplines.

NT960 M.S. Research

NT980 Ph. D. Research