

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 nanobiotech will also be discussed.

NT512 NanoTechnology

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

PH603 Quantum Mechanics I

Hilbert space, measurement processing, transforming operation, rotation, various operators, theory of groups, applied quantum mechanics, Wigner-Eckart theorem, perturbation theory about normal state, perturbation theory about time, and application of atom, molecule and solid will be presented.

PH604 Quantum Mechanics II

Scattering theory (Lippmann-Schwinger equation, Born approximation, optical theorem, Eikonal approximation, inelastic electron-atom scattering, and Symmetry in scattering), Dirac-delta function, Compton scattering, and introduction of quantum electronic mechanics will be presented.

PH611 Advanced Solid State Physics I

This lecture provides understanding about fundamental principles of solids. Symmetry of solids, Brillouin zone, energy band theory, k.p. theory, effective mass of electron, spectrum of phonon energy, will be presented.

PH611 Advanced Solid State Physics II

As a continuation of Advanced Solid State Physics I, transport phenomena of electrons, optical property of solids, photonic transition phenomena, magnetic theory of solids, electronic structure of low-dimensional physics systems, electron-phonon interaction, superconductivity, Green function, and local function theory of multi systems will be focused on.

PH711 Physics of Magnetism

This lecture provides understanding of fundamental phenomena of magnetic materials. Kramers theorem, Jahn-Teller effect, diamagnetism. paramagnetism of classic and quantum approach, Pauli paramagnetism, Weiss model, Heisenberg model, Stoner- band - model, spin fluctuations and Synchrotron Radiation in studies of magnetism: NMRS, XMS, XMRS, XMCD.

PH726 Semiconductor Optics

This lecture mainly deals with the interaction between lights and electron-hole pair at the band gap of semiconductors. Specifically, optical adsorption, nonlinear adsorption, semiconductor quantum well, semiconductor lasers and semiconductor optical devices will be included.

BS465 Biological Engineering II

This course introduces fundamental aspects of biochemical engineering such as fluid dynamics, heat transfer, mass transfer, unit operation, and bio-reactors and discusses the application of those principles.

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 provides understanding about atomic level of life phenomena through biopolymer research.

CH502 Quantum Chemistry I

The purpose of this course is to give graduate students in Chemistry an ability to understand electronic structures and spectroscopic properties of atoms and molecules by means of theoretical techniques, such as *ab initio* and semi-empirical methods. Topics include: Hartree-Fock Approximation, configuration interaction, *ab initio* and semiempirical methods. (Prerequisite: 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 desorption of gas molecules on the metal surface and the implication of these phenomena to the theory of catalytic behavior.

Topics include: Principle of the surface analysis methods such as Auger, XPS, LEED, SEXAFS, Chemisorption on surfaces, and Catalytic reactions on surfaces.

MAE614 Statistical Thermodynamics

This is an introductory course of the statistical thermodynamics with its applications. Macroscopic thermodynamics is reexamined from the perspective of atomic-molecular theory. Topics include kinetic theory of an ideal gases, classical and quantum statistics, quantum mechanics, partition functions and thermodynamic properties.

MAE662 Precision Positioning System Design

This course is designed for graduate students in which design principles are introduced, then, several structure design techniques such as kinematic design, flexure mechanism design, guide mechanism design, etc. are studied. Later, 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 presentations at the end of the semester.

MAE693 MEMS (MicroElectroMechanical Systems)

This course discusses engineering problems arising from the miniaturization of electromechanical systems. Topics included are physical principles and scaling laws, microphenomena, basics of electronics and mechanics, transduction principles, detection and actuation methods, micromachining process and technology, microelectromechanical materials, technology integration and other multi-disciplinary issues involved in the microelectromechanical devices and systems. Term projects and presentations are required.

MAE810 Special Topics in Thermal & Fluid Engineering

This course discusses theories and applications of the selected topics about thermal & fluid engineering.

BiS471 Bio-Inspired Electromechanical Sensuating Systems

This course provides working principles of sensing and actuation mechanism in an organism. Quantitative analysis methods of function and principle analogy between organisms and electromechanical systems are discussed. Term projects and presentation for information communication, medical diagnosis, computer and environment based on bio-analogic electromechanical sensuating systems are required.

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

Genomics 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. 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 provides properties, behaviors and controls of nanoparticles, and introduces machining processes of nanomaterials. Stability, repeatability 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 their fabrication processes, and nano testing and characterization 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 properties and behaviors of micromaterials based on mechanical, material, physical, chemical and biological analysis of biomedica and

their reactions. Topics include: 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.

CBE434 Nanochemical Technology

This course deals with theories and experimental methods for nanochemical processes including the characteristics of nanosystems, the fabrication of nanostructures and the prediction of the nanostructure-macroscopic property relations under equilibrium and nonequilibrium conditions. The building blocks for nanostructures considered here 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. Finally, the applications of nanochemical technology will be given emphasizing the areas of optoelectronics, nanophotonics, smart materials, and fuel and solar cells.

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. So, this introductory course is to establish the basic concepts of interface science and engineering. The basic structure consists of three parts: surface structure and energy, molecular alignment at surface, and electrical and dispersive interaction at interface. Covered by this course are 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 discusses electronic and optical function of nano-scale molecular and material structures. This course deals with material & device design, structure control, material processing and introduces how the nano-structured materials have opto-electronic properties.

CBE612 Design of Catalysis

Classical theories of catalysis, for example geometrical theory, electronic theory and semiconductor theory, are introduced. Also, newly developing molecular orbital theory for theoretical illustration of catalysis follows. It also describes a correlation between catalytic performance containing catalytic activity, selectivity and so on and catalytic structure and intermediates. Research techniques for catalytic reaction mechanism are dealt with at the molecular level. And, it contains theoretical analyses for both homogeneous and heterogeneous catalysis.

CBE632 Colloids and Surface Chemistry

This course discusses properties of microchemical system and surface chemistry. This course deals with surface phenomena of micro particles, interaction and stability between lyophilic and lyophobic colloids, influence of macromolecules and polyelectrolytes emulsions, films, gels, micelles, microemulsions dispersion, etc.

CBE682 Organic Nanostructured Materials

This course introduces structure control, molecular orientation, nano analysis technology to help understanding the structure of organic nano-material and inducing advanced function.

CBE712 Surface Phenomena

This course covers the fundamental principles and applications of surface science at the molecular level. Especially, XPS, Auger spectroscopy, ISS, UPS, SIMS, LEED, ELLS, SEXAFS, RHEED, Work function, and TDS equipment are dealt with.

NQE489 Special Topics in Nuclear and Quantum Engineering I

This course covers the special field of nuclear and quantum engineering which is not covered by other courses. The content can vary and is selected 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 subjects 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 understanding of numerical analysis, artificial intelligence and simulation methodologies which can be applied to 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 part, the course covers expert system, neural network, fuzzy theory, and other artificial intelligence concepts. Students will also understand about uncertainty problems and sensitivity studies 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 equipment. 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 neutron optical device and neutron scattering instruments. A few practical examples of neutron scattering experiments are also discussed.

MS523 Electron Microscopy and Experiment

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.

MS525 Introduction Quantum Mechanics

Fundamental concepts of quantum mechanics such as wave properties, the uncertainty principle and the Schrödinger equation will be covered. Especially, particles in a box, harmonic oscillators, atomic spectra, molecular bonding theory, experimental methods and basic theories of determining the molecular structure will be stressed.

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. There is further description about 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 Mechanical Properties of Thin Films

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 materialism mesoporous materials, and biomaterials prepared by sol-gel nano process are introduced

MS671 Mechanical Properties of Thin Films

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 Mechanical Properties of Thin Films

A group project will be a major component of the course. The purpose of this project is to bring together students with 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 covered. Also magnetic anisotropy, magnetostriction and magnetic domains will be intensively covered. Lastly, engineering applications of magnetic materials in electromagnetic equipments, permanent magnets and external magnetic recording devices for computer application engineering who have studied general physics and calculus at under graduate course will be acceptable for 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 real semiconductor devices.

EE561 Physical Electronics

This course covers fundamental VLSI device physics including PN junction, 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: EE302, EE461)

EE564 Integrated Circuit Process

In this course, we study in depth the most up-to-date processing techniques in the field of integrated circuits (IC). Various processes on which today's IC technology is based are examined including deposition, lithography, etching, and packaging. This course will cover newly emerging areas of microelectromechanical systems (MEMS) processing techniques.

EE661 Solid State Physics

This course is for graduate students. The course will cover the basic concepts of 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. (Prerequisite : EE565)

EE662 Quantum Electronics

This course deals with the interaction between light wave and material, the principle of laser oscillation, various laser systems, operation principle of semiconductor laser, laser beam modulation, optical theory, Brillouin and Raman scattering, etc.

EE663 High Frequency Electronic Devices

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.

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

This listing is for lectures on topics related to Nanotechnology that are not listed in majors and electives.

NT966 M.S. Seminar

This listing is to give students chances to attend seminars on current research in the fields of nanoscience / technology and other disciplines.

NT986 Ph.D Seminar

This listing is to give students chances to attend seminars on current research in the fields of nanoscience / technology and other disciplines.

NT960 M.S. Research

NT980 Ph.D. Research