Dept. of Physics

Physics is a fundamental science aimed at discovering the basic principles governing our universe, and applying these to the everyday life. Most of today's scientific knowledge is based on the laws of physics, and therefore Physics is considered to be one of the most fundamental fields in the science and engineering and has broad impacts in the real world. The education and research goal of the Department of Nano and Electronic Physics is to explore the quantum phenomena in the nanometer scale, to apply the principles of Physics to the electronic systems, and to cultivate the manpower needed in the 21st century industry. The research and education within the department will be performed by carrying out the cutting-edge experiments and developing new methods to overcome the limitations of the conventional methodologies in nanometer scale. The department also focuses on the theoretical and numerical studies on the physical phenomena in the nanometer region.

The department of Physics consists of 10 faculty members who are actively pursuing researches on many forefront fields in physics and providing high-quality education. The main research topics include physics of magnetic material, geometrical optics, plasma physics, computational condensed matter physics, semiconductor physics, surface physics, and nanoelectromechanical systems. The department offers the educational program which encourages the students to study the multidisciplinary aspects of nanoscience through the various courses offered by the department. Also for students, many research opportunities will be available through on-going research programs in the department.

☐ Courses

❑ Core Courses

- **Classical Mechanics (3)**

  Classical Mechanics is a field of physics which describes the motion of the macroscopic bodies including celestial objects like star and everyday machineries. In this course, Lagrangian and Hamilton mechanics based on Hamiltonian theory in the classical mechanics will be studied in depth. The scope of the subject will include not only the typical aspects of classical mechanics area but also small oscillation, collision of two particles and relativistic theory.

- **Electrodynamics (3)**

  Electrodynamics deals with the physical phenomena related to electric and magnetic field and related dynamics of the fields and the dynamics of the charged particles. The scope of the subject includes time independent and dependent electric fields in vacuum and in dielectrics, magnetic fields associated with constant and variable currents, magnetic materials, Maxwell's equations, electromagnetic wave propagation in medium, generation of electromagnetic wave, relativistic 4vector treatment of electromagnetic entities.

- **Quantum Mechanics (3)**

  Quantum Mechanics is a fundamental subject which is backbone of the modern science. The course will introduce quantum mechanical concepts like operators, expectation value, wave function, etc. The course will also discuss angular momentum operators, harmonic oscillator problem, atomic hydrogen problem, perturbation theory, scattering theory, identical particles, radiation, second quantization, etc.

- **Physics Research Ethics & Thesis Study (3)**

  Survey& overview the impact of Physics and Physics research result on society and scientic community with ethical point view. And Suggest sound research approach.

❏ Physics Major Courses

- **Modern Optics (3)**

  This class discusses the concepts and the experimental applications of various optical techniques, utilized in modern physics based on optical theory.

- **Solid State Physics (3)**

  Solid State Physics deals with the many aspects of the solid state materials, including semiconductors, magnetic material. Physical properties of solid state material will be discussed with both classical and quantum mechanical theories. The scope of the course will cover atomic, molecular and crystal structure, energy levels of electrons, and binding energies in molecules and solids, etc.

- **Advanced Solid State Physics (3)**

  Advanced Solid State Physics is an advanced course for the student who has background on the graduate level solid state physics. The course will mainly focus on the quantum mechanical phenomena in the solid state material. The scope of the course will include band theory, superconductors, magnetism of matter, heat capacity of materials and optical properties of solids, etc.

- **Statistical Mechanics (3)**

  Statistical Mechanics is a fundamental subject in the physics which deals with collective many-body phenomena in nature. The course will introduce the concepts of micro-canonical ensemble, canonical ensemble, grand-canonical ensemble, free energy, entropy, chemical potential, partition function, etc. Also, the course will introduce the equilibrium thermodynamics and elementary statistical mechanics. The knowledge of Statistical Mechanics is essential to the understanding of the modern solid state physics of semiconductor and magnetic material.

- **Advanced Statistical Mechanics (3)**

  Advance Statistical Mechanics is for the student who are familiar with the basic Statistical Mechanics. In the course, the advanced subjects of statistical mechanics like advanced thermodynamics, superfluids, Ising model, phase transition and Landau theory will be studied. Introductory nonequilibrium theory is also another topic to be discussed in the course.

- **Mathematical Physics (3)**

  Firm knowledge of mathematics is very important in the study of the physics since many theoretical works on physics are expressed in mathematical equations, graphs, and mathematical models. This course is to provide the basic background and skills in mathematical physics which is needed for the further study and research in physics. The scope of the course will include Ordinary Differential Equation, Complex Variable, Calculus of Variation, Numerical Method, etc.

- **Advanced Mathematical Physics (3)**

  This course presents the advanced topics in mathematical physics which is essential for the understanding of the current researches in Physics. The course is for students who are familiar with the basics of graduate-level mathematical physics. Especially, the students majoring in mathematical physics are required to take this advanced course. The scope of the course will include Special Function, Integral Transforms, Integral Equation, Green's Function, group, etc.

- **Computational Physics (3)**

  The course presents the computational techniques and software development skills. Also, the students will learn network and software development tools including parallel batch processing systems, code management systems, debuggers and optimizers, auto documentation generators, and web utilities. Computational Physics is closely related to the success of the modern computational material physics.

- **Semiconductor Physics (3)**

  Semiconductor is very essential to the success of the modern solid state electronic devices including integrated circuits, transistors, diodes, LEDs, etc. The physical properties of the semiconductors are subjects of study in Semiconductor Physics course. Since semiconductor is also a solid state material with well defined crystal structure, basic knowledge of solid state physics is required. The scope of the course will include lattice vibration, band structure and conductivity of semiconductor, etc.

- **Advanced Semiconductor Physics (3)**

  Advanced Semiconductor Physics course is for the students who have graduate level knowledge on the semiconductor physics. The topics covered in the course are interface of semiconductor, optical absorption, semiconductor laser, amorphous semiconductor and doping effect. Forefront research topics and issues of the semiconductor physics will be also discussed in the course.

- **Advanced Classical Mechanics (3)**

  In this course further canonical formalism development begins by introducing Hamilton Jacobi theory. Classical theory of fields is also presented. Examination and comparative understanding of classical field concept will be discussed to provide a unified view of classical and quantum mechanics. The prerequisite for this course is at least one semester of post graduate level classical mechanics.

- **Advanced Electrodynamics (3)**

  The main topic of this course is electromagnetic radiation and its interaction with matter. Outline of the course is electromagnetic wave generation, propagation in a medium, its interaction with medium, dielectric loss, electromagnetic properties and various phenomena in optics. Four vector formalism and covariant vector of relativity will also presented.

- **Advanced Quantum Mechanics (3)**

  Main purpose of this course is to put together the principles of relativity and quantum theory that are necessary to perform calculations of the electromagnetic scattering of electrons and positrons, as well as, the emission and absorption of photons. Second quantization, Dirac equation, calculation of covariant perturbation, elementary process of scattering will be presented. At least one semester of post-graduate level quantum mechanics is prerequisite to this course.

- **Spin-spectroscopy (3)**

  The interpretation of micro spin structure of materials will be introduced. The role of the microscopic spin structure in the nonvolatile data storage, quantum computer, magnetic sensor are studied. Application of spin technology for micro electronic devices and nano electronic devices is manipulated.

- **Spin and Nano Physics (3)**

  Spin and Nano Physics is a course designed to introduce the basics of the nano materials and devices. Following the brief instroduction of the nano materials and device, the course discusses the theoretical and experimental works on the physical phenomena in nanostructures and their applications in the field of spintronics.

· **Advanced Material Physics (3)**

This course discusses the advanced topics in material physics, which is not covered in post-graduate level material physics and its goal is to help students to be familiar with fore-front of material physics. Topics are new magnetic materials, ferroelectric materials, optical device materials, nano-structured material and left-handed materials. Prerequisite is graduate course on material physics.

· **Magnetism (3)**

This course begins with the basic concept of magnetism. Topics of this course covers diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, Curie-Weiss law, Zener's super exchange model, Anderson's double exchange model and application to oxide materials. Basic of magnetic spectroscopy with neutron and X-ray is also presented. Prerequisite for this course is undergraduate course of solid state physics.

· **Advanced Magnetism (3)**

This course presents the advanced topics in magnetism, which is not covered in post-graduate level magnetism course and its goal is to help students to be familiar with fore-front works on the field of magnetism. Topics are new magnetic materials such as GMR, CMR, diluted semiconductor, Multi-ferroic materials, and nano-magnetic particles. Prerequisite is graduate course of magnetism.

· **Plasma Physics (3)**

This course provides the student with the basic theory of plasma, which covers atomic collision, Maxwell Boltzman distribution, Debye screening, glow discharge process, frequency dependence of plasma, interaction with electromagnetic waves, plasmasolid interaction and Beam plasma. Prerequisite for this course is one semester post-graduate level classical electrodynamics.

· **Methods in Experimental Physics (3)**

This is the lecture about the methodology in physics experiments. In this lecture, students are asked to study various fields in experimental techniques including electrical curcuits, vacuum technique, glass work, machining job. etc. Various kinds of electrical instruments are utilized in modern physics experiments. Thus thorough understanding of the electrical instruments and electrical circuits used in physics experiments is very important and it will be discussed in detail. Other techniques like vacuum technology will also be reviewed. Typical experimental methods in physics will also be presented and discussed.

· **Advanced Plasma Physics (3)**

This course discusses the advanced topics in plasma physics, which is not covered in post-graduate level plasma physics and its goal is to help students to be familiar with the fore-front of plasma research. Some topics on Magneto hydrodynamics (MHD) and instability theory, fusion plasma, space plasma will be presented. Special emphasis on plasma reactor design for low temperature semiconductor process is discussed.

- **Quantum Optics (3)**

  This course begins with basic tools of quantum optics such as Atom-field interaction.

- **Physics of Crystal Diffraction (3)**

  This course covers basic crystallography, classification of solids, group theory, basic theory of X-ray diffraction, kinematic theory, dynamical theory, Debye Waller line broadening, Reliability factor, diffuse scattering, and neutron diffraction to crystalline solid. Prerequisite to course is one semester undergraduate level solid state physics and electromagnetism.

- **Physics of Thin Films (3)**

  This course focuses on the physical aspect of thin films. Thin film has different characteristics, which cannot be found in bulk. Starting from the basic principle of various growing, the course discusses modern thin film growing method such as PECVD, LPCVD, MOCVD, ALE and its physical, chemical and mechanical properties. Important analytical tools for film characterization (XPS, AES, SIMS, and XRD) are also presented.

- **Advanced physics of Thin Films (3)**

  This course is intended to serve as an advanced course on thin films and their properties as well as their applications. In addition, the growth mechanism of thin films and various film growth techniques such as PECVD, LPCVD, and MOCVD will be discussed in depth. Especially, this course focuses on various physical properties of superconducting, metallic, semiconducting, magnetic thin films.

- **Crystal Growth (3)**

  This course introduces the theory of crystal growth. The topics include Czochralski crystal growth, float zone crystal growth, epitaxial crystal growth, and atomic layer crystal growth as well as general introductions to crystal and crystal growth. We will look at the physical mechanisms of crystal growth in light of modern technologies with emphasis on their applications in nanotechnology.

- **Topic in Solid State Physics (3)**

  This is a special course on solid state physics. Rather than discussing the general theories of solid state physics, this course focuses on topics in solid state physics, which are not covered in regular courses on solid state physics. This course also discusses the advanced topics on modern solid state physics theories and experiments with emphasis on mesoscopic and microscopic systems.

· **Topic in Magnetism (3)**

This is a special course on the physics of magnetism and magnetic materials. Rather than discussing the general theories of magnetism, this course focuses on topics in magnetism, which are not covered in regular courses on magnetism. This course also discusses the advanced topics on modern physics of magnetism and magnetic materials such as spintronics and multiferroic materials as well as their applications.

· **Topic in Semiconductor (3)**

This is a special course on the physics of semiconductor and semiconducting materials. Rather than introducing the general theories of semiconductor, this course focuses on topics in semiconductor, which are not covered in regular courses on semiconductor. This course also discusses the advanced topics on modern physics of semiconductor and semiconducting materials with emphasis on applications in the field of nanotechnology.

· **Topic in Plasma (3)**

This is a special course on physics of plasma. Rather than introducing the general theories of plasma physics, this course focuses on topics in plasma physics, which are not covered in regular courses on plasma physics. This course also discusses the advanced topics on current plasma physics theories and experiments with emphasis on their applications in modern technologies.

· **Research in Magnetism (3)**

This course presents the current topics in physics of magnetism. This course introduces current theories in the field of magnetism and offers chances to review some of experiments such as spintronics and dilute magnetic semiconductors. This course is intended for a small group of students involved in various research projects to discuss the current topics in magnetism, which are actively pursed in the field of magnetism and their applications.

· **Seminar in Solid State Physics (3)**

This course consists of a series of weekly presentations of current research topics in solid state physics. This course is designed to expose students to the topics and excitement of the research frontier. Each lecture will be given by a different researcher who will describe his/her field and his/her own work. Also each student will be given a chance to present a research paper related to solid state physics.

· **Applied Optics (3)**

This course is intended to serve as a graduate level introductory course on optics. This course focuses on introducing general theories of optics such as geometric and physical optics, aberrations, optical instrumentation, interference, and polarization in optics. In addition, brief description of current researches in optics and their applications in modern technologies will be presented.

· **Advanced Applied Optics (3)**

This course is intended to serve as a graduate level advanced course on optics. Based on general theories of optics such as geometric and physical optics, aberrations, optical instrumentation, interference, and polarization in optics, this course will discuss the advanced topics in optics research. Also, this course will present applications of optics in the fields of nanotechnology and biotechnology.

· **Mossbauer Spectroscopy (3)**

The Mossbauer spectroscopy has been one of the key research techniques in the field of magnetism. The Mossbauer spectroscopy allows the understanding of fundamental physical processes in magnetic materials. This course introduces basic theories of Mossbauer spectroscopy and its applications. This course is intended for students, who are planning to research in the field of magnetism.

· **Advanced Mossbauer Spectroscopy (3)**

This is an advanced course on Mossbauer spectroscopy. This course discusses the advanced topics on Mossbauer spectroscopy and its applications in the field of magnetism. This course describes the fundamentals of Mossbauer effect and operation principles of Mossbauer Spectroscopy. This course also teaches the interpretation of Mossbauer measurements.

· **Surface Physics (3)**

This course is intended to serve as a graduate level course on the surface physics. This course describes the fundamental physical processes on surfaces. Also, this course covers the basic theories of surface physics and their applications. In addition, this course describes the various analysis methods on the solid surface using ARS, SIMS, XPS, AFM, SEM, TEM and RBS.

· **Semiconductor Process (3)**

This course introduces the physical properties of semiconductor devices and fabrication processes of amorphous and crystalline semiconductor devices. In addition to the introduction of the basics of semiconductor physics, this course presents technological aspects of semiconductor processes such as crystal growing, vacuum technology, diffusion barrier and amorphous process.

· **Quantum Solid State Physics (3)**

This is an advanced course on solid state physics. This course is intended for students, who are planning to research in the field of both theoretical and experimental solid state physics. Especially this course focuses on the quantum theories of solid and reviews some of experiments in light of those. The topics include phonons, lattice specific heat, neutron scattering in solids, Landau diamagnetism, de Hass Alphen effect, and energy band theory.

· **Topic in Surface Physics (3)**

This is a special course on surface physics. Rather than introducing the general theories of surface physics, this course focuses on topics in surface physics, which are not covered in regular courses on solid state physics. This course also discusses the advanced topics on current surface physics theories and experiments with emphasis on their applications in modern technologies.

· **Topic in Optics (3)**

This is a special course on optics. Rather than introducing the general theories of optics, this course focuses on topics in optics, which are not covered in regular courses on optics. This course also discusses the advanced research topics on current theories and experiments in the field of optics, with emphasis on their applications in modern technologies.

· **Research in Semiconductor (3)**

This course presents the current topics in physics of semiconductor. This course introduces current theories in the field of semiconductor and offers chances to review some of experiments. This course is intended for a small group of students involved in various semiconductor research projects to discuss the current topics, which are actively pursed in the field of semiconductor research and their applications.

· **Research in Plasma (3)**

This course presents the current topics in physics of plasma. This course introduces current theories in the field of plasma and offers chances to review some of experiments. This course is intended for a small group of students involved in plasma research projects to discuss the current topics in plasma physics, which are actively pursed in the field of plasma research and their applications.

· **Seminar in Semiconductor (3)**

This course consists of a series of weekly presentations of current research topics in semiconductor physics. This course is designed to expose students to the topics and excitement of the research frontier. Each lecture will be given by a different researcher who will describe his/her field and his/her own work. Also each student will be given a chance to present a research paper related to semiconductor physics.

· **Seminar in plasma (3)**

This course consists of a series of weekly presentations of current research topics in plasma physics. This course is designed to expose students to the topics and excitement of the research frontier. Each lecture will be given by a different researcher who will describe his/her field and his/her own work. Also each student will be given a chance to present a research paper related to plasma physics.

· **Research and Seminar in Magnetic hyperfine (3)**

This course presents the current topics in physics of hyperfine interaction on magnetism. This course introduces current theories in the field of magnetism and offers chances to review some of experiments such as magnetic semiconductors and multifunctional materials. This course is intended for a small group of students involved in nanomagnetism research projects to discuss the current topics in magnetism. Each lecture will be processed by seminar and discussion on current special topics.

· **Research in Optics (3)**

This course presents the current topics in physics of optics. This course introduces current theories in the field of optics and offers chances to review some of experiments. This course is intended for a small group of students involved in optics research projects to discuss the current optics topics, which are actively pursed in the field of optics research and their applications.

· **Seminar in Optics (3)**

A series of weekly presentations of current research topics in optics. This course is designed to expose students to the topics and excitement of the research frontier. Each lecture will be given by a different research who will describe his/her field and his/her own work and each lecture will be processed by seminar and discussion on current special topics.

· **Seminar in Nano Solid Spectroscopy (3)**

This course will introduce emerging nano materials and structures as well as measurement and spectroscopy techniques in sub-micron region.

· **Advanced Magnetic Field Theory (3)**

Magnetic field theory will be explored for application of magnetic properties of a solid. Molecular field theory, direct exchange interaction, super exchange interaction, double exchange interation will be introduced. On basis of those theories, ferromagnetic, anti ferromagnetic, ferrimagnetic order will be studied.

- **Magnetic Hyperfine Spectroscopy (3)**

This course consists of a series of weekly presentations of current research topics in nuclear solid state physics. This course is designed to expose students to the topics and excitement of the research frontier. The energy splitting of hyperfine interaction related to zero phonon state, Debye temperature, gamma ray resonance will be introduced. Also each student will be given a chance to present a research paper related to solid state physics.

- **Quantum computing (3)**

We learn quantum technologies combined with the principles of quantum mechanics in the quantum computer invented on the basis of quantum physics. We understand fundamental concepts such as quantum bits(qubits), quantum universal gates, quantum algorithms, and underlying technologies for quantum computers currently being implemented.

- **Quantum Device and Instrumentation (3)**

Quantum physics-based device and measurement techniques can significantly improve sensitivity and resolution in information gathering. In this course, students learn single photon source and single photon detector technologies for various quantum sensors and quantum imaging, which are emerging as the necessary element technologies in quantum technology development.

- **Special Lectures on Quantum Information (3)**

New information technology beyond the IT technology, which is the core of modern technology, is being born based on quantum physics. This course focuses on device and materials for quantum information technology that are currently under development or are expected to come on in the foreseeable future. In particular, this lecture includes the fundamental theories and the experiments of quantum computing.

- **Independent Study (3)**

Students can carry out the independent research projects of interest under the supervision of faculty members.

☐ Faculty Members

Park, Key Taeck
Yonsei Univ., B.S.
Yonsei Univ., M.S.
Tokyo Univ., Ph.D.
Solid State Physics
key@kookmin.ac.kr

Lee, Chang Woo
Kyungpook National Univ., B.S.
KAIST, M.S.
KAIST, Ph.D.
Semiconductor Physics
cwlee@kookmin.ac.kr

Shim, In Bo
Kookmin Univ., B.S.
Kookmin Univ., M.S.
Yonsei Univ., Ph.D.
Ceramic Engineering
ibshim@kookmin.ac.kr

Jang, Zeehoon
Seoul National Univ., B.S.
Seoul National Univ., M.S.
Iowa State Univ., Ph.D.
Solid State Physics
zeehoonj@kookmin.ac.kr

Kim, Sam Jin
Sogang Univ., B.S.
Yonsei Univ., M.S.
Yonsei Univ., Ph.D.
Magnetic Nano Physics
sjkimmmm@kookmin.ac.kr

Kang, Jie Hun
Seoul National Univ., B.S.
Phohang Univ. of Science and Technology, M.S.
Univ. of Warwick, Ph.D.
Surface Physics
spjk@kookmin.ac.kr

Kouh, Taejoon
Boston Univ., B.S.
Brown Univ., M.S.
Brown Univ., Ph.D.
Nano and applied Physics
tkouh@kookmin.ac.kr

Moon. Sucbei
Sogang Univ., B.S.
Gist Univ., M.S.
Gist Univ., Ph.D.
Optics
moons@kookmin.ac.kr

Noh. Heeso
Korea Univ., B.S.
Korea Univ., M.S.
Northwestern Univ., Ph.D.
Photonics
heesonoh@kookmin.ac.kr

Lee, Hyuk Jae
Yonsei Univ., B.S.
Yonsei Univ., M.S.
Yonsei Univ., Ph.D.
Quantum Computer
lhjae@kookmin.ac.kr