Photonics and Sensors

I Educational Goal

The educational goal of this department is to help master and doctor course students get the technological convergence insights that can be applied in a creative way to various fields of industry. To this end, two specialized programs are opened: Photonics course and Sensors course, which is closely related with the undergraduate curriculum. And in order to teach various recent modern knowledges and technologies in these fields, our faculty educate theoretically and experimentally students in this department.

Ⅱ Educational Objective

The educational objective of this department is to make students solve the issued problems requested from the domestic medium industries with the practical photonics and sensor technology. The students must announce, report, and publish their works and research results in official domestic and/or international conferences and academic jounals to be evaluated their research results.

Field of Majors	Outline
Sensors	Our research areas are as follow ; Magnetic instrumentation, Magnetic sensors, Magnetic materials, thin films, Spintronics, Non-destructive inspection of materials
Photonics	Our research areas are as follow ; Opical System Design, Aberration Theory, Optical System Assessment, Measurement of Aspherical Surfaces, Medical Optics, Medical Laser, Optical Measurement and Optical measuring System, Lens Design and Optical Shop Testing, Moire Topography for the shape reconstruction of 3D objects, LED measurement, Surface Plasmon Resonance Ellipsometry, Grating interferometry ,Aberration theory of a self-imaging system, Aberrations of an optical system for a Gaussian beam

Ⅲ List of Full-time Faculty

Name	Position	Degree(University)	Field of Instruction	Area of Research
Jo Jae Heung	Professor	PhD (KAIST), MS (KAIST), BS (Korea University)	Applied Optics/ Optical Engineering	(1) Optical Measurement and Optical measuring System (2) Lens Design and Optical Shop Testing (3) Moire Topography for the shape reconstruction of 3D objects (4) LED measurement (5) Surface Plasmon Resonance Ellipsometry
Rim Cheon Seog	Professor	PhD (KAIST), MS (KAIST), BS (Hankuk University of Foreign Studies)	Physics/ Applied Optics/ Optical Engineering	(1) Opical System Design (2) Aberration Theory (3) Optical System Assessment (4) Measurement of Aspherical Surfaces (5) Medical Optics (6) Medical Laser
Son De Rac	Professor emeritus	Dr. -Ing, Universitaet der Bundeswehr Hamburg(1990)	Magnetism Physics	(1)Magnetic instrumentation (2) Magnetic sensors

Ⅳ Course Description

• **PS613 Radiation physics 3 credits**

Through this course, it is possible to acquire the basic characteristics of radiology and its action in order to acquire medical images using radiation, to understand the phenomenon that occurs in the treatment of tumors, and to develop the ability to cope with the situation. In addition, it learns to maximize the patient's clinical benefit at the hospital and to protect himself and his patients from radiation exposure or exposure. This course explores the process of preparation for radiation-related license examinations, including the ancient atomic theory of modern physics and nuclear physics as well as Rutherford's alpha particle scattering experiment, Bohr's atomic model, the meaning and nature of X-ray discovery, and nuclear markings, alpha and beta, gamma ray properties, natural radiation elements that form collapsing series, discovery of nuclear fission, fission products, interaction between charged particles and materials.

• **PS614 Solid State Physics I 3 credits**

Solid state physics is a discipline that understands the properties of solid state materials most widely used in the field of science and technology. It is to understand the thermal, electrical, genetic, magnetic and optical properties of solids. The main contents of the lecture are crystal structure based on point group and space group, direction of crystal, crystal plane, X-ray diffraction for studying crystal structure, neutron scattering, diffraction condition and Bragg law, lattice vibration (phnon) This course introduces the thermal, acoustic and optical properties of solids by phonons, free electrons of metals, Fermi surface, electrical conductivity, cyclotron resonance and Hall effect, energy band of solids, momentum of electrons and effective mass.

• **PS615 Solid State Physics II 3 credits**

Solid state physics is a discipline that understands the physical properties of solid materials most widely used in the field of science and technology and to understand the thermal, electrical, genetic, magnetic, and optical properties of solids. Solid State Physics 2 is based on Solid State Physics 1 and is based on the polarization of permanent dipoles in the field of crystal structure and energy bend, impurity state, electrical conductivity, magnetic field, pn junction as semiconductor device, transistor, and the properties of solids, ferromagnetism, paramagnetic, antiferromagnetic and quasi-ferromagnetic properties in the field of magnetism, the theory of superconductivity and the Josephson effect.

• **PS616 Ceramic Semiconductors 3 credits**

This field learns about conceptualization of new material ceramics which is a non-metallic solid of minerals made by artificial high-temperature heat treatment, material mixing and firing temperature for the production of ceramics. We will establish the concept of robustness, heat resistance and corrosion resistance of new material ceramics, etch method in LSI and DRAM semiconductor memory field, interface problem between ceramic and metal heat treatment, thin film device fabrication and LSI simulation. In particular, it deals with memory and bipolar theory, and covers package structure, design, and defect measurement for transistor structure and memory device fabrication.

• **PS617 Low Temperature Physics 3 credits**

This course aims to study the broad concepts that can be understood in basic and applied fields based on the characteristics of superconductivity phenomenon and resistivity and semi-magnetic properties found in the early 20th century. Among the characteristics for Type-I and Type-II superconductivity, the resistance appearing below the superconducting transition temperature becomes zero, and the half-magnetism, the minus effect, the surface current, the super current and the normal current of the surface magnetic field due to the external magnetic field, We will establish the basic concept as the next generation device through the carrier, Type-I BCS theory, spin density wave theory, charge density wave theory, Type-II Kotschberg-Landau theory, and comparison of high temperature and low temperature superconductors. Especially, the fundamental phenomenon of superconductivity, the phase transition effect and the semi-magnetic effect of low temperature measurement, Little-Parks theory, the theory of low temperature superconductivity, the relationship between super current and phase current, the correlation between transmission depth and coherence length, Resistance characteristics and magnetic field conversion, Josephson effect, passive (for optical and satellite communication) and active (Josephson) devices, superconducting SQUID devices and magnetic levitation trains.

• **PS618 Crystal Structure of Solids 3 credits**

This course deals with solid state and crystalline state, X-ray diffraction experiment and optical method, and growth method for students who want to major in solid state physics. To summarize, we describe the nature and symmetry of crystal, sharing, ion, metal, hydrogen defects, etc. and There are 2 and 3 dimensional spatial lattice and 14 crystal Bravais lattice for the lattice. Planar lattices, plane groups, equivalent positions in the space group, equivalent positions in the symmetric relationship, space group, and the crystal projection of the Miller index, rational index, direction index, Miller-Bravais index, the analytical procedure, reciprocal lattice of boc, foc lattice, reciprocal lattice point forming lattice, explanation of experimental method, powder method, powder diffraction method, single crystal oscillation method and rotation method, double crystal diffraction technique, stress and strain tensor in a tensor, 4^{th} order tensor, the theorem of a Bloch, potential and wave, and discuss periodic boundary conditions.

• **PS619 Superconductors 3 credits**

Based on the zero-resistance, high-temperature superconducting phenomena and characteristics of resistivity found in 1986, the goal is to understand a wide range of concepts in theory, experimentation, and applications of high-temperature superconductivity. Particularly, the characteristics of Type-II ceramic superconductivity, the change of transition temperature for the change of planar layer structure, the magnitude of the surface magnetic field by the external magnetic field, the minus effect, the magnitude of surface resistance for operating high frequency, We will establish the basic concept as a next-generation device through hole and charge carriers in superconductors, spin density wave theroy, charge density wave theory, Type-II Ginsburg-Landau theory, and comparison of high-temperature and low-temperature superconductors. Especially, it is applied to the high magnetic field of high-temperature superconductors, the superconducting wire is manufactured, the high integration device using Josephson effect, the application to passive (optical and satellite communication) and active (Josephson) devices, the superconducting SQUID device and the application to magnetic levitation train And so on.

• PS620 Medical-Radiation Technology 3 credits

The development of semiconductor materials and devices is the foundation of the modern information industry. In order to understand semiconductor devices, energy band structure of semiconductors, semiconductor statistical physics, energy transfer, diffusion, transport phenomenon of nonconductors, absorption and reflection of light in semiconductors, photo conductivity and luminescence phenomenon of semiconductors will be studied.

• PS621 Physics of Magnetism I 3 credits

The physical properties of ferromagnets are described as microscopic physical phenomena and macroscopic physical phenomena, and the physical properties of magnetic materials are understood in relation to macroscopic magnetic phenomena. The main contents of this lecture are to understand the magnetization of the ferromagnets, the theory of ferromagnetism and quasi-ferromagnetism, the concept of magnetic domain, magnetic anisotropy, magnetostriction, magnetic wall properties, understand variables.

• PS622 Physics of Magnetism II 3 credits

The physical properties of ferromagnets are described as microscopic physical phenomena and macroscopic physical phenomena, and the physical properties of magnetic materials are understood in relation to macroscopic magnetic phenomena. The main contents of this lecture are to understand the relationship of magnetization curves and magnetic domains, non-magnetization processes, dynamic magnetization processes, magnetic aftereffect, and induced magnetic anisotropy, and understand the macroscopic physical parameters of magnetic materials.

• PS623 Magnetic Materials 3 credits

Magnetic materials are classified into soft magnetic materials and hard magnetic materials in terms of application and they are to understand two kinds of major magnetic properties and major magnetic materials. The main contents of the lecture cover the main magnetic properties required for the design of permanent magnet magnetic circuits in which power devices using soft magnetic materials are used and permanent magnet materials, and for silicon steel sheets, permalloys, amorphous alloys and ultrafine grains in the case of soft magnetic materials. In the case of hard magnetic materials, Alico, Sr ferrite, and permanent magnet materials are studied.

• PS624 Applications of Magnetics 3 credits

This course is designed to introduce students to the physical property of magnetic materials and applications. Major applications area includes transformers for power equipments, manetic sensors, motors, inverters, magnetic recording media, magnetic circuit etc.

• PS625 Magnetic sensors 3 credits

This course studies various magnetic sensors. Magnetic sensors are utilized for military defence and industrial areas due to high reliabliyt. Topics cover important magnetic phenomena such as magnetostriction, magnetoresistance, magnetic hysterisis, magnetic flux. This cource includes fluxgate sensors, Hall sensors and SQUID.

• PS626 Selected Topics in Geometrical Optics 3 credits

The objective of this course built up for lens designers is to explain the basic topics in geometrical optics, such as the paraxial raytracing technique based on Gaussian optics, the Seidel theory of aberration, and the finite raytracing method. The contents of the lecture are as follows: (1) Gaussian optics, (2) Optical invariants – Abbe invariant and Lagrange invariant, (3) Paraxial raytrace equations, (4) Calculation of the monochromatic aberrations (i.e., spherical aberration, coma, astigmatism, field curvature, and distortion) (5) Calculation of chromatic aberrations (i.e., axial and lateral colors), (6) Finite raytrace equations, (7) Introduction to computer-aided lens design, and so on.

• PS627 Selected Topics in Wave Optics 3 credits

The objective of this course is not only to introduce the wave theory of light described by a scalar function, but also to present the electromagnetic vector theory of light described by Maxwell's equations. The topics are selected as follows: (1) Complex representation of light waves, (2) Temporal and spatial coherences of quasi-monochromatic waves, (3) Interferometers, (4) Thin film optics, (5) Guided-wave optics, (6) Polarization and crystal optics, (7) Scalar theory of diffraction, (8) Gratings and Fresnel-zone plates, (9) Diffraction theory of imaging, (10) Optical transfer function of an imaging system, (11) Optical image processing, and so on.

• PS628 Selected Topics in Laser Optics 3 credits

The objective of this course is not only to introduce the basic principle of laser operation, but also to explain many of widely different laser devices. The topics are selected as follows:

(1) Gaussian beam optics - characteristic parameters of a Gaussian beam, (2) Resonator optics - stability conditions and transverse electromagnetic modes, (3) Absorption and emission of light - Einstein coefficients and population inversion, (4) Rate equation approximation, (5) Continuous operation of lasers, (6) Pulsed operation of lasers – Q switching and mode locking, (7) Laser amplifiers, (8) Properties of different types of lasers, (9) Applications of lasers, and so on.

• **PS629 Fourier Optics 3 credits**

The Fourier transform is one of the well-known tools for the analysis of a time-varying signal, which has also found the applications in the field of wave optics such as diffraction, imaging, optical data processing, and holography. This lecture will cover the topics: (1) Fourier analysis of linear systems, (2) Characteristics of recording materials, (3) Fourier transforming properties of lenses, (4) Analysis of complex coherent optical systems, (5) Analysis of incoherent image processing system, (6) Concept of holography – Gabor hologram, Leith-Upatnieks hologram, and rainbow hologram, (7) Application of holography - holographic data storage, and so on.

• **PS701 Quantum Theory of Solids 1 3 credits**

This course is designed to provide students to profound knowledge of solid state using qunatum theory. The first half of the course will be devoted to learning the fundamental material, electrical, and chemical properties of the solid . Major topics cover Phonon field quantization, Phonon mode, specfic heat and conduction mechanism, energy band theory etc.

• **PS702 Quantum Theory of Solids 2 3 credits**

This course covers fundamental property of solid using quantum theory. Especially semiconductor property including effective mass, intrinsic and extrinsic semiconductor, Hall effect is studied based on energy band theory. Electrical and Optical property of solid are also touched in depth.

• **PS703 Electronic materials 3 credits**

This course studies properties and application of electronic materials. Introduction to the structure and properties of important electronic materials such as direct and indirect band gap materials. Crystallography, crystal defects and diffraction. Phase transformations: phase diagrams, diffusion, nucleation and growth. Processing technology of etching, film formation, doping, metallization is also covered in the field of LSI, LED and Display.

• **PS704 Medical Physics 3 credits**

Applications of physics in medicine. Topics may include X-ray, MRI imaging techniques, interaction of radiation and tissue, nuclear medicine, visual auditory processes, and basic physics. of the human body. Graduate-level requirements include students to complete supplemental assignments at the graduate level.

• **PS705 Selected Topics in Spectroscopy 3 credits**

This course studies Spectroscopy to investigate material property utilizing interaction of photon and atoms in matter. Topics include Spectroscopy, Structure and components, sensors, cooling system and related quantum theory. Numerical analysis and processing of spectroscopic data is also presented for understanding molecular structure.

• **PS706 Magnetic Measurements 3 credits**

This course covers measurements of magnetic propertis showen nonlinear magnetic hysteresis. Measurements include ring core method, dc permeameter method, Epstein method for soft magnetic materials, electromagnet and pulse methods for hard magnetic materials.

• **PS707 Selected Topics in Solid State Physics 1 3 credits**

This course studies solid state physics. Topics cover crystal structure, crystal diffraction and reciprocal lattice, crystal binding, lattice vibration, thermal properties.

• **PS708 Selected Topics in Solid State Physics 2 3 credits**

This course studies solid state physics. Topics cover free electron Fermi gas, energy bands, semiconductors, optical properties, superconductivity, and magnetic properties.

• **PS709 Physics of Non-Destructive Testing 1 3 credits**

This course covers principles of various non-destructive sensing techniques for getting structural infomations of samples. Specially ultrasonic method and x-ray method, eddy current, magnetic probe etc are presenteded, and their advantages and applications are touched.

• **PS710 Physics of Non-Destructive Testing 2 3 credits**

This course covers principles of various non-destructive sensing techniques for getting structural infomations of samples. Specially magnetic powder, radiation method and electron method etc are presenteded, and their advantages and applications are touched.

• **PS711 Selected Topics in Electric Wave Engineering 3 credits**

Review of transmission line theory; microstrip lines and planar circuits; RF/microwave network analysis; scattering parameters; impedance transformer design; filter design; hybrids and resonators; RF/microwave amplifier design; RF transceiver design; RF/microwave integrated circuits.

• **PS712 Optics Colloquium I 3 credits**

The objective of this course is to present a general description of recent developments in optics and related sciences of current interest. All the topics are not only chosen but also lectured by invited authors who have contributed substantially to the progress of optical engineering.

• PS713 Optics Colloquium Ⅱ 3 credits

The objective of this course is to present a detailed description of recent developments in optics and related sciences of current interest. All the topics are not only selected but also lectured by invited authors who have contributed substantially to the progress of optical engineering.

• PS714 Nonlinear Optics 3 credits

This field originated with the experiment of Franken on optical second harmonic generation and the analysis of Bloembergen on optical wave mixing. Today it has found applications in all areas of science and technology. This course will cover the topics of nonlinear electromagnetic phenomena in the optical region which normally occur with high-intensity laser beams - (1) Electro-optical (or Magneto-optical) effects, (2) Optical rectification, (3) Sum (or Difference) frequency generation, (4) Harmonic generation, (5) Parametric amplification and oscillation, (6) Stimulated Raman scattering, (7) Stimulated Brillouin scattering, (8) Two-photon absorption, (9) Four-wave mixing, (10) Self-focusing, (11) Transient coherent optical effects, and so on.

• PS715 Optical Shop Testing 3 credits

The objective of this course is to present a detailed description of all tests applicable in the optical shop to optical components and systems. By so doing, they can be compared and the most advantageous can be chosen for use. The contents of the lecture are as follows: (1) Newton, Fizeau, and Haidinger interferometers, (2) Twyman-Green interferometers, (3) Common-path interferometers, (4) Shearing interferometers, (5) Multiple-beam interferometers, (6) Multi-pass interferometers, (7) Foucault, Wire and phase modulation tests, (8) Ronchi test, (9) Hartmann test, (10) Star test, (11) Holographic and Moire techniques, (12) Null test, (13) Length and angle measurements, and so on.

• PS716 Optical Shop Training 3 credits

The objective of this course is to practice the procedures for generating optical components and devices, ranging from optical surfaces and thin films, through holograms and zone-plates, to laser cavity and components. The topics under the supervision of practitioners in the optical shop are selected as follows: (1) Generation of optical surfaces - cutting, grinding, polishing, testing and figuring procedures, (2) Thermal evaporation procedure for depositing aluminum films on glass, (3) Procedure for generating holograms and zone-plates, (3) Procedure for designing a laser cavity, (4) Procedure for testing an optical fiber, (5) Observation of nonlinear effects on anisotropic crystals, and so on.

• **PS717 Optical Instruments 3 credits**

The objective of this course is to present a detailed description of the construction and image formation of visual optical instruments, ranging from simple magnifiers, through microscopes and telescopes, to the more sophisticated instruments based on interference and diffraction. The contents of the lecture are as follows: (1) Geometrical theory of optics, (2) Geometrical optical instruments - the eye, magnifiers, microscopes, telescopes, relay systems, cameras, collimators, (3) Physical theory of optics, (4) Physical optical instruments - interferometers and diffractive devices, (5) Ophthalmic instruments – Focimeters, keratometers, optometers and binocular vision testing instruments, (6) Aberration and image quality, and so on.

• **PS718 Method of Lens Design 3 credits**

The objective of this course is to introduce and practice using a software of computer-aided lens design which facilitates any optimized design. The contents of the lecture are as follows: (1) Paraxial optics - computation of paraxial constants, (2) Apertures and pupils - computation of irradiance, (3) Monochromatic aberrations - computation of aberration coefficients, (4) Optical materials - model glasses and calculation of chromatic aberration, (5) Ray tracing - finite raytrace algorithms, (6) Image evaluation - spot diagram and transfer function, (7) optimization – error function construction, (8) Tolerancing, (9) Gaussian beams - laser cavity design, (10) Diffractive optics -types of diffractive surfaces, (11) Partial coherence – Van Cittert-Zernike theorem, (12) Polarization -Jones calculus, and so on.

• **PS719 Laser Spectroscopy 3 credits**

It is now over seventy years since "resonance radiation and exited atoms by A.C.G. Mitchell and M.W. Zermansky, first appeared. This course includes the detail processes with demonstrating how the technique of atomic spectroscopy and lasers have been applied to a wide range of problems in atomic and molecular physics. This course is an extended course of a set of lectures on atomic physics given to undergraduate courses. This course will provide an excellent basis for an advanced undergraduate coures in atomic physics, optical metrology, and quantum physics. And this will also prove valuable to those engaged in research in the fields of atomic physics, lasers, astrophysics, and physical chemistry.

• **PS720 Fiber Optics 3 credits**

Recent advances in the development of low-loss optical fibers have revolutionized the field of telecommunications, and fiber-based networks from a key part of international communication systems. This comprehensive course provides an introduction to the physical principles of optical fibers and discussions in detail their use in modern optical communication systems and sensor technology. The course begin by setting out the basic propagation characteristics of single-mode and multimode optical fibers. Finally, this cover optical sources, optical detecters, and fiber optic communication system design. And it treat a wide variety of related topics such as doped fiber amplifiers, soliton propagation, dispersion compensation, fiber

Bragg gratings and fiber sensors, as well as measurement techniques for the characterization of optical fibers.

- **PS721 Photonics 3 credits**

The invention of the laser and the subsequent development of low-loss optical fibers started a revolution in the communications industry about 35 years ago. This course is directed at the hardware aspects of photonics. Six major topics are coverd; (1) fundamental principles of electromagnetic theory, (2) optical waveguide, (3) coupling and numerical analysis of eaveguides, (4) detectors and noise, (5) optical emission and lasers, (6) modulators and sensors.

- **PS722 Thin Film Optics 3 credits**

In the design of a thin film multilayer, it is requires to find an arrangement of layers which will give a performance specified in advance, and this is much more difficult than straightforward calculation of the properties of a given multilayer. The design and evaluation is then completed by calculating the performance on a computer. This course contains the handling of more complex expressions and applications of the thin film coatings.

- **PS723 Integrated Optics 3 credits**

The development of miniaturized and ruggedized optical circuits, containing a number of optical and also electronic components integrated on the same substrate, and performing useful optical functions-this is the goal of the key technologies for future systems of communication, of instrumentation, and of general signal processing. It is expected to combine and to complement the estabilished technologies of microelectronics, optoelectronics, and fiber-optics. This course will mentioned three topics of priciples or a variety of integrated optics technologies, materials, and nonlinear optics with interesting components.

- **PS724 Physiological Optics 3 credits**

There recently has been increased interest in the applications of optical techniques in biomedical research and clinical diagnoistics. The contributions to this course are focussed on the folloeing topics; biomedical applications of (1) unconventional imaging in microscopy, (2) imaging processing, (3) interferometry and holography, (4) speckle techniques and spectroscopy, (5) optometry, (6) and moire methods.

- **PS725 Selected Topics in Modem Optics 1 3 credits**

- **PS726 Selected Topics in Modem Optics 2 3 credits**

- **PS727 Illumination Optics 3 credits**

This course consists of lecture and practice. Topics cover the theory of illumination optics, source modeling, telecommunication component modeling, beam projector modeling, LED lamp modeling, LCD backlight modeling, scattered light modeling in optical system, and faceted reflector modeling.

• PS728 Electro-Optics Display 3 credits

Electro-optical displays serve as the most significant user-machine interface in this age of information. Demand for displays continues to grow and diversify as more and more application areas become identified. The roots of display technology go back to such disciplines as electronics, chemistry, physics, electro=optics, communications, psychology, vision, and many more. It is this aspect of diversity that often poses a stumbling block for integration of the total field of diaplay technology. This course attempts to introduce the principles, applications, and issues pertaining to some of these electro-optical displays.

• PS729 Colorimetric Optics 3 credits

The characteristics of color vision differ even among persons with normal color vision. Persistent efforts to substitute colorimetry for visual judgement have marked the twentieth century. This course aims to present a comprehensive discussion of basic principles, certain technical topics and recent developments in color science which are of interest to scientists, engineers and designers. The main topics to be presented are the physical basis of color specification, spectrophotometry, color mixture, determination of tristimulus values, color of light and objects, color difference, color-order systems, color-matching functions, chromatic adaptation, and the diverse application of the CIE chromaticity diagram.

• Research for the Master's Degree 1
• Research for the Master's Degree 2
• Research for the Doctoral Degree 1
• Research for the Doctoral Degree 2
• Research for the Doctoral Degree 3