HANYANG UNIVERSITY COURSE CATALOG

GRADUATE COURSES IN ENGLISH

GREETINGS

If industrialization represented the previous generation, globalization is the essence in today's generation. Globalization is a worldwide phenomenon which involves interconnections between nations and integrations within the global economy, and South Korea is no exception. Despite the difficulty we face as an ethnically homogeneous nation, Korea has made a tremendous progress in joining the rest of the world in the international arena. Hanyang University, as one of the nation's most innovative and progressive institutions, has actively pursued diversification and internationalization to spearhead Korea's participation in the world affairs.

One of Hanyang's main goals is providing opportunities for students to develop into active participants in the international arena as global leaders. It is time to pursue a higher quality of education for Hanyang University in the globalization era. Communication with global institutions, globalization strategy through investing in cutting-edge technologies, and specialization strategy by merging advanced fields will serve as a crucial platform for becoming the 'Center of Global Research and Education'.

Going further to help our students become better equipped to navigate through this globalized world, we have dedicated considerable effort and resources to create an extensive curricula for classes conducted in English. Composed of a diverse interest of studies, our classes are designed to promote integrative thinking, creativity, and critical reasoning skills to provide future global leaders with the intellectual tools and strong ethics to lead our society into a brighter future.

Provost and Senior Vice President
Kwan-Soo Lee

CONTENTS

SEOUL CAMPUS

Hanyang University

Seoul Campus

HANYANG UNIVERSITY

Department of
Chemistry

Classification: Major Elective

Topics in Disease Diagnostic

Course Code		CHM6039
Credits	Class hr	Lab hr
3	3	0

Detecting diseases such as cancer in their earliest stages can make a huge difference in patient treatment. In this course, we will cover the basic principle of diagnostic, related biological mechanism and effect of the biosensor. Students will choose a specific disease, such as Alzheimer's disease, anthrax, food poisoning, cancer, and etc., and discuss its recent diagnostic technology; antibody, peptide, aptamer, surface plasmon resonance (SPR), piezoelectricity, gold nanoparticle, surface-enhanced Raman spectroscopy (SERS), quartz crystal microbalance (QCM) and etc. The main purpose of this subject is to enlarge the knowledge of disease diagnostic and to encourage the ability to create the novel experimental field. In addition, students will learn the current topics and approaches in the biosensor system.

Frequency of offering: Every Other Fall
Prerequisite: Biochemistry

Classification: Major Elective

Advanced Organic Chemistry

Course Code		CHM8010
Credits	Class hr	Lab hr
3	3	0

The goal of this class is to introduce synthetic organic chemistry in advanced level. Total synthesis is, by definition, the complete chemical synthesis of a complex molecule from simple starting materials. The target molecules are often natural products, medicinally important active ingredients, or organic compounds of various interests. In this practice, the main aim is to develop a route that allows an access to the target molecules, which often accompany the discovery of new reactions and reagents. Starting with a brief introduction to retrosynthetic analysis and synthetic methodologies, we will move to survey a few classical, yet sophisticated, examples of total synthesis reported in the literature. We will follow each synthetic step featured in the synthesis and discuss the tactics and strategies employed within. Also covered are some of the basic stereo-chemical analyses, organometallic chemistry and asymmetric catalysis. This course requires knowledge of the undergraduate level of organic chemistry.

Frequency of offering: Every Other Fall
Prerequisite: Organic Chemistry I and II

Classification: Major Elective

Advanced Biochemistry

Course Code		CHM8011
Credits	Class hr	Lab hr
3	3	0

The understanding of molecular structure & function is of central importance to students undertaking a major in the biological or chemical fields. This subject will cover the various topics in biochemistry, such as biological functions of the molecules which make up living organisms: water, amino acid and proteins, enzyme, nucleic acids, carbohydrate, and lipids. Also, we will focus on molecular mechanisms of protein function. The structure and functional mechanisms of proteins involved in energy transduction, fundamental principles of bioenergetics, cellular signaling, and transmembrane transport are studied in greater detail. In addition, we will learn about metabolic pathways to understanding biosynthesis and catabolism. Based on the knowledge we learn, the current topics of each subject will be also covered.

Frequency of offering: Every Spring
Prerequisite: Biochemistry

Classification: Major Elective

Advanced Polymer Chemistry

Course Code		CHM8018
Credits	Class hr	Lab hr
3	3	0

This course introduces advances in polymer chemistry and physics. In order to exactly figure out how polymer chain architectures affect phase behaviors and physical properties of complex polymer systems, graduate students will study the principles of polymer synthesis, polymer structures, polymer physics, and polymer analysis. In particular, the structural properties of polymer chains will be studied further in order to understand the chain-to-chain interactions as well as polymer fluidities. These deep understandings will allow the graduate students to have more practical senses in exploring a variety of polymer applications, including engineering of nanoscale polymer materials, fabrication of polymer thin films, development of functional materials, synthesis of biopolymers, and development of environmental materials. Some case studies to be done in the final stage will help the graduate students get more experiences in engineering the functional polymers that are already commercialized in industries.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Chemistry Seminar 1

Course Code		CHM9034
Credits	Class hr	Lab hr
3	3	0

Chemistry seminar is a graduate course in chemistry department that should be useful to graduate students in various branches of chemistry, as well as, physics, life sciences, and chemical engineering. The topics covered in this course will include both traditional disciplines of the chemistry including physical, analytical, organic, inorganic, and bio and collaborative, multi-disciplinary research fields, such as nano-science and technology, materials, and polymer chemistry. One of the purposes of the chemistry seminar is to introduce recent research trend in chemistry to graduate students by exposing them to the researches of nationally and internationally recognized scientists. A series of presentations will be given by invited researchers from universities, govern institutions, and industries, which provide opportunities to engage a variety of fields other than their own majors.

Frequency of offering: Every Spring
Prerequisite: None

Classification: Major Elective

Enzymology

Course Code		CHM9037
Credits	Class hr	Lab hr
3	3	0

The beginning of Enzymology can be traced back to the early nineteenth century though biocatalysts have been used for thousands of years to make bread and brew alcoholic beverages. W. Kuhne in 1879 introduced the name ‘enzyme’. An enzyme is a catalyst which speeds up the rate of a specific reaction and while doing so it remains chemically unchanged and without loss of activity at the end of the reaction. This course will cover the catalytic mechanisms of enzyme reactions, with an emphasis on reaction mechanisms of enzyme and its substrate. Students who are interested in the mechanisms of enzymes, enzymes used in drug synthesis, enzyme structure and function of enzymes and enzyme engineering will find this course valuable. After completion of the subject, the students will understand in detail regarding enzymatic activity and the importance of enzymes for organisms.

Frequency of offering: Every Other Fall
Prerequisite: Biochemistry

Classification: Major Elective

Protein Biotechnology

Course Code		CHM9046
Credits	Class hr	Lab hr
3	3	0

As a biological component, the biological functions of proteins are extremely diverse and it has a great potential for human benefits. For this reason, protein biotechnology is one of promising fields in biotechnology. This course aims to provide students with a comprehensive overview of protein biotechnology in three main themes: protein biochemistry, protein analysis and purification, and recombinant protein expression and harvesting. This course will try to minimize such repetition by emphasizing the general principles that are common for proteins. At the end of course, students may understand the concept of protein biotechnology and learn how proteins can be analyzed, purified and harvested for a further application. Also, they will be armed with rational thoughts being able to analyze and interpret scientific data in the field of protein biotechnology.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Advanced Topics in Biotechnology

Course Code		CHM9047
Credits	Class hr	Lab hr
3	3	0

Biotechnology is a broad discipline in which biological processes, organisms, cells or cellular components are exploited to develop new technologies. New tools and products developed by biotechnologists are useful in research, agriculture, industry, and the clinic. This subject will cover the recent biotechnology with variety topics; bacteriology, virology, genetics, cell biology, genomics, proteomics, immunology, environmental microbiology and bioprocessing. In particular, students will learn about the disease and environment related advanced biotechnology, such as medicine, therapy, diagnostic, and gene-regulating mechanisms, and its effects. The course is supplemented with laboratory exercises, demonstrations and field trips that illustrate the basic techniques of biotechnology including laboratory topics and finally the course concludes with a consideration of bioethical issues relating to this powerful new technology.

Frequency of offering: Every Other Spring
Prerequisite: Biochemistry

Classification: Major Elective

Bionanotechnology

Course Code		CHM9048
Credits	Class hr	Lab hr
3	3	0

Nanobiotechnology, bionanotechnology, and nanobiology are terms that refer to the intersection of nanotechnology and biology. This study is one that has only emerged very recently, bionanotechnology and nanobiotechnology serve as blanket terms for various related technologies. The most important objectives that are frequently found in nanobiology involve applying nano-tools to relevant medical/biological problems and refining these applications. This subject will cover the basic principle of bionanotechnology, structure & functional relationship of bio-nano molecules, nano-biosensors, nano-bio medical transport vehicle, and nano-bio genetics. A highly potent catalysis and a high specificity of biological macromolecules provides a wide spectrum of application in a modern nano science. Main purpose of this subject is to enlarge the knowledge of bionanotechnology and to encourage the ability to create the novel experimental field.

Frequency of offering: Every Other Spring
Prerequisite: Biochemistry

Classification: Major Elective

Molecular Cell Biochemistry

Course Code		CHM9089
Credits	Class hr	Lab hr
3	3	0

Grasping the concept of cellular biology at the molecular levels is a prerequisite for understanding and defining the biological phenomena. In this course, students will examine the essential role of biological and chemical components including nucleic acids, carbohydrates, lipids and proteins, in consideration of many different areas of cellular biology about the synthesis and function of these macromolecules; regulation of gene expression; membrane and organelle structure and function; energy production and consumption in metabolism; and cellular communication. Finally, this course will help students to grasp the concept of molecular cell biology and get a scientific approach to understand biological phenomena at the molecular levels. Training of rational thoughts and proficiency in scientific reading and writing will be emphasized throughout the course.

Frequency of offering: Every Other Fall
Prerequisite: None

HANYANG UNIVERSITY

Department of

Environmental Science

Classification: Major Elective

Environmental Stress Physiology

Course Code		ENS8076
Credits	Class hr	Lab hr
3	3	0

It is designed to provide graduate student with comprehensive exposure to the subject of Environmental Stress Physiology. Plant and algal adaptation mechanisms to different environmental stress will be studied for understanding how plant and algae are evolved thru harsh environmental changes. Student should learn about the most recent knowledge of plant and algae. To understand the adaptive physiology of environmental stress, plant and algal behaviors to different stress regarding form morphological aspect to molecular adaptation will be studied. They will actively participate in presenting and debating in English.

Frequency of offering: Every Other Fall
Prerequisite: None

Classification: Major Elective

Advanced in Polar Environmental Science

Course Code		ENS8088
Credits	Class hr	Lab hr
3	3	0

This course is designed to provide graduate student with comprehensive exposure to the subject of Advanced in Polar Environmental Science. Many organisms live in the polar regions, arctic and Antarctic, and they show us enormously dive way of living, and adaptations in the regions. This subject will focus on the diverse of environments, and adaptations of living organisms in the polar regions. Student should learn about understanding the characteristics of polar regions and the adaptation of diverse organism in the polar regions. They will actively participate in presenting and debating in English.

Frequency of offering: Every Other Spring
Prerequisite: None

HANYANG UNIVERSITY

Department of
Life Science

Classification: Major Elective

Advanced Plant Biotechnology

Course Code	BIO5008	
Credits	Class hr	Lab hr
3	3	0

This course is designed to provide graduate students with comprehensive exposure to the subject of Plant Biotechnology. Topics related to biotechnology in regard to plants and algae will be reviewed. The following topics are covered: (1) Gene and genome analysis: analysis of genes and gene networks showing the potential for industrial application; gene expression studies; (2) Transgenic technologies: Production and analysis of transgenic crops and algae, gene insertion studies; gene silencing; factors affecting gene expression; molecular farming; field trial analysis; commercialization of modified plant and algae; (3) Functional genomics: bioinformatics; gene function studies for applied uses; (4) Physiological studies: pathways relevant to an application; secondary metabolites; manipulations of physiology. This course requires knowledge about the basic plant biology.

Frequency of offering: Every Other Spring
Prerequisite: Plant Biology

Classification: Major Elective

Biochip & Biosensor

Course Code	BIO6038	
Credits	Class hr	Lab hr
3	3	0

This course will give an introduction of biochip/biosensor to graduate students who major in biology. In order to understand the design and application of biosensors, instructions will be given on the general concepts of biomolecular interactions, biological recognition elements, measurement techniques, and statistical presentation. Many types of biochips/biosensors will be introduced, ranging from colorimetric devices to optical systems. Applications in the field of biomedicine and environmental science will be especially emphasized with issues on sensitivity, selectivity and high-throughput. Lecture topics include (but are not limited to) DNA/protein chips, organ-on-a-chip, enzyme biosensors, aptamer biosensors, and nanosensors. This course will be given as a general lecture in the first part, followed by students' presentations based upon articles and on-going researches.

Frequency of offering: Every Other Fall
Prerequisite: General Biology, General Chemistry, Biochemistry

Classification: Major Elective

Advanced Nanobiotechnology

Course Code		BIO6039
Credits	Class hr	Lab hr
3	3	0

Biology merged with nanotechnology holds promise for many potential applications in biotechnology and biomedicine. This course offers graduate students who major in biology an in-depth insight into nanobiotechnolgy. The lecture will deal with basic biophysical/biochemical principles, cutting-edge techniques, and toolkits of nanobiotechnology linked to biology, chemistry, and physics. With recent advances in biology and nanotechnology, the class will especially focus on how nanotechnology is being combined with biological & biomedical fields, ranging from fundamental studies to applied researches including biochip/biosensor, drug & gene delivery, diagnostics & therapy, and drug discovery. Lecture topics include (but are not limited to) the overview on nanobiotechnology for the biologist, nanoparticle-based applications I&II, and recent topics in nanotech-based biological studies. We will also discuss how current researches of graduate students can be fused with nanobiotechnolgy.

Frequency of offering: Every Other Fall
Prerequisite: General Biology, General Chemistry, Biochemistry

Classification: Major Elective

Method in Phylogenetic Analysis

Course Code		BIO6053
Credits	Class hr	Lab hr
3	3	0

Methods of phylogenetic analysis have provided a powerful tool for the study of the evolutionary history of organisms, their genes and genomes. The goal of this course is to familiarize students with modern phylogenetic methods used to analyze data sets. The sessions will provide hands-on experience with several software packages (e.g. Winclada, NONA, TNT, MEGA, ClustalX) in widespread use for sequence alignment, phylogeny reconstruction, and evolutionary analysis. The students will be taught how to analyze molecular sequence data, and also how to choose and code morphological characters and infer phylogenies based on both data sets. The course will emphasize hands-on experience with software tools for obtaining sequence data, constructing trees (e.g., using parsimony, distance) and related analyses of molecular and morphological data. Other topics will include resampling techniques and tree comparison methods, the advantages and disadvantages of common approaches for inferring trees, and recent advances in animal systematics and evolution.

Frequency of offering: Every Spring
Prerequisite: None

Classification: Major Elective

Evolutionary Life Science Seminar

Course Code		BIO6066
Credits	Class hr	Lab hr
3	3	0

This course will be based on reading and discussing most recent scientific publications with the evolutionary topic. The publication will cover human, animal and plant evolution with a special reference to the evolution of behavior as well as the recent trends of research methods. Each class will cover a different paper, which students will have to read, prepare some questions and discuss about the selected publications. For the presentations, students should prepare some advice for the presenter regarding attitude, presentation skills, presentation files, and etc. Also, the presenter should prepare some answers for the listener. The publications will be chosen both by the professor and the students. Some publications will be chosen from famous papers and recent trends of morphological, evolutionary, and phylogenetic researches.

Frequency of offering: Every Fall
Prerequisite: None

Classification: Major Elective

Analysis of Next-Generation Genomic Data

Course Code		BIO6070
Credits	Class hr	Lab hr
3	3	0

The goal of this class is to introduce the advanced next-generation sequencing (NGS) technologies and their biological applications in the research level. This course will briefly cover core knowledge of genomics, review diverse platforms and chemistries for high-throughput sequencing, and discuss a sort of NGS data, such as whole genome sequencing (WGS), exome sequencing, mRNA-seq, miRNA-seq, and chip-seq. Student will also learn computational algorithms, linux-based programs, and analysis-pipelines for the analysis of those NGS data. Class sessions comprise of lectures, paper reading, and projects.

Frequency of offering: Every Other Fall
Prerequisite: Genetics, Computational Biology

Classification: Major Compulsory

Advanced Cellular Biochemistry

Course Code		BIO6073
Credits	Class hr	Lab hr
3	3	0

Cell biology known as molecular or cell biology, is a branch of biology that studies the different structures and functions of the cell and focuses mainly on the idea of the cell as the basic unit of life. Cell biology explains the structure, organization of the organelles they contain, their physiological properties, metabolic processes, signaling pathways, life cycle, and interactions with their environment. This is done both on a microscopic and molecular level as it encompasses prokaryotic cells and eukaryotic cells. Knowing the components of cells and how cells work is fundamental to all biological sciences and is also essential for research in bio-medical fields such as cancer, and other diseases. Research in cell biology is closely related to genetics, biochemistry, molecular biology, immunology, and developmental biology. Advanced Cellular Biochemistry is the study of the molecular biochemical processes in living organisms on the basis of Cell Biology. It deals with the structure and function of cellular components, such as proteins, carbohydrates, lipids, nucleic acids, and other biomolecules. The molecular cellular biology of cell signaling, cell metabolism, the endocrine system, genomic stability will also be extensively studied. In addition chemical biology aims to answer many questions arising from molecular biochemistry by using tools developed within chemical synthesis. The goal of this course is to introduce students to the basic concepts of the cellular and molecular biology to begin applying these concepts to advanced biological studies.

Frequency of offering: Every Spring
Prerequisite: None

Classification: Major Elective

Tools for Biodiversity Research

Course Code		BIO6074
Credits	Class hr	Lab hr
3	3	0

This course will provide students with new tools for their research projects on different aspects of biodiversity. It will include the work with the statistical programs such as Primer V.6., which is useful in ecological, macro- and micro- ecological and environmental monitoring projects. It will also focus on a modern, integrative web tool called Scratchpads. The content uploaded to a Scratchpad can be kept available only for the collaborators, who have a log in to the Scratchpad, or it can be published to everyone in the web. Collaborators can also use scratchpads as a platform where they can communicate with each other, where they can write and upload personal files to blogs for the public, build bibliographic databases, build molecular data base, etc.

Frequency of offering: Every Fall
Prerequisite: None

Classification: Major Elective

Topics of Spermatogenesis

Course Code		BIO7068
Credits	Class hr	Lab hr
3	3	0

Testis, a reproductive organ, is the male gonad in animals and has two major functions, spermatogenesis and androgen synthesis. Both functions of the testis are regulated by gonadotropic hormones including luteinizing hormone (LH) and follicle stimulating hormone (FSH). Spermatogenesis is, by definition, the process in which spermatozoa are produced from primordial germ cells by way of mitosis and meiosis. Starting with a brief introduction to the general principles of spermatogenesis, students will take several topics regarding the spermatogenesis. The topics are gonadal development, germ cell development, meiosis, spermatogenesis, assisted reproductive technology (ART), and the latest advances in the research in male reproductive biology. This class is opened to graduate students with a major in life science, especially developmental biology. Each student will be required to select a research subject of interest and to present it. Therefore, the students will comprehend a fundamental knowledge of andrology.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Topics in Developmental Genetics

Course Code		BIO7090
Credits	Class hr	Lab hr
3	3	0

By applying updated information, one can understand how development works in molecular ways. Molecular revolution has affected developmental biology probably more than any other biological disciplines. MicroRNAs, microarrays, mammalian cloning, knockout mice, transcription factors, paracrine factors, chromatin remodeling proteins, and the signaling pathways contribute to understanding the developmental process. This class will be progressed with the known facts from a series of recent studies in the field of molecular and cellular biology of gametogenesis and preimplantation embryos. This class aims to rear the ability of comprehensive reading, paper writing, presentation, and Q&A for graduate students with a major in life science. To this end, each student will be required to select a research subject of interest and to present on it. Therefore, the students will learn the principles for gene regulatory network during development and differentiation of cells, tissues, and organs.

Frequency of offering: Every Other Fall
Prerequisite: None

Classification: Major Elective

Reproductive Physiology

Course Code		BIO8063
Credits	Class hr	Lab hr
3	3	0

During development of the reproductive system, the male and female reproductive organs are differentiated, and physically mature under the control of hormones derived from hypothalamus, pituitary, and gonad. The structure and function of the reproductive tissues are maintained or changed by regulation of gene expressions, which occurs precisely and complexly. Starting with a brief introduction to the reproductive system, this class will offer the comprehensive understanding of the study model for mammalian reproduction, regulation of gene expression in reproductive tissues, and recent progress in the reproductive biology. This class is opened to graduate students with a major in life science. Each student will be required to select a research subject of interest and to present on it. Therefore, the students will comprehend a fundamental knowledge of reproductive biology.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Plant Molecular Biology

Course Code		BIO9039
Credits	Class hr	Lab hr
3	3	0

The course aims to provide theoretical and practical insights into modern plant and algal cell and molecular biology. Also included will be lectures, seminars and literature discussions by invited experts. Some of the principle subjects taught will include: Gene structure, organization and expression in plants and algae; plant and algal transformation, regeneration and molecular/biochemical analysis of transformants; Plant and algal genetics and biotechnology including discussions on genetically modified organisms in agriculture and other commercial applications; Functional genomics and proteomics; Plant responses to environmental stresses abiotic and biotic. From this course student will learn a deeper knowledge of various cellular, biochemical, genetic and molecular processes within plants and algae and understand the basic concepts and techniques important for understanding these processes, as well as the scientific principles that underlie and drive the rapid development of molecular biology.

Frequency of offering: Every Other Fall
Prerequisite: Introductory Plant Biology

Classification: Major Elective

Introduction to Geometric Morphometric

Course Code	BIO9100	
Credits	Class hr	Lab hr
3	3	0

Geometric morphometric (GM) is the study of shape variation and its covariation with other variables where shape is defined as all the geometrical information that remains after location, scale and rotational effects are (mathematically) filtered out from an object. The course aims to introduce basic concepts of geometric morphometrics and to emphasize outreach of the method in various biological fields providing relevant examples. Along two to three weeks, the course will cover necessary theoretical foundation of the landmark based GM and important multivariate morphometric methods. The sessions will provide hands-on experience with techniques and software for data acquisition (tpsDig2) and software for analyses (mostly MorphoJ and occasionally R). Students will gain experience to perform basics GM routines (Procrustes fit, extraction of symmetric and asymmetry shape variation, size-corrected and sex-corrected shape variation) and analyses (PCA, DA, Regression analysis, Procrustes ANOVA, etc.) and to interpret results.

Frequency of offering: Every Spring
Prerequisite: None

Classification: Major Elective

Applied Radiation Biochemistry

Course Code	BIO9101	
Credits	Class hr	Lab hr
3	3	0

Ionizing radiations may be emitted in the decay process of unstable nuclei or by de-excitation of atoms and their nuclei in nuclear reactors, X-ray machines, cyclotrons and other devices. During radioactive decay gamma rays are often produced alongside other types of radiation such as α or β rays. When a nucleus emits an α or β particle, the daughter nucleus is sometimes left in an excited state which, after de-excitation, returns to a lower energy level by emitting a γ ray in much the same way that an atomic electron can jump to a lower energy level by emitting visible light. Both natural background radiation from cosmic and terrestrial sources, and man-made radiations, cause ionization of atoms or molecules, which may cause injury to cells. Living organisms are continuously exposed to ionizing radiations from natural radiation. In addition, exposures occur as a result of human activities and medical practices. Applied Radiation Biochemistry is the study of the action of ionizing radiation on living things. The human body is made up of many organs, and each organ of the body is made up of specialized cells. Ionizing radiation can potentially affect the normal operation of these cells. In this subject, we will discuss the potential for biological effects and risks due to ionizing radiation.

Frequency of offering: Every Spring
Prerequisite: None

Classification: Major Elective

Advanced Cancer Biology

Course Code		BSE6081
Credits	Class hr	Lab hr
3	3	0

Cancer develops over time as mutations and genetic changes accumulate in cells. The traits that a normal cell acquires as it slowly transforms into a precancerous one and ultimately into cancer are called the "Hallmarks of Cancer". They are the characteristics that distinguish cancer cells from normal cells. Although each hallmark contributes to cancer, it is not until a cell exhibits the complete set of characteristics that cancer has fully developed. This framework illustrates that cancer develops through a set of discrete transformations (genetic changes). Cancer is also a group of diseases in which cells are aggressive (grow and divide without respect to normal limits), invasive (invade and destroy adjacent tissues), and/or metastatic (spread to other locations in the body). To understand these specific characters of cancer, we need to know about the nature of cancer, molecular targets of cancer therapy, and current development of cancer treatment. This subject is an upper level Biochemistry elective. The goals of this course are to introduce students to the basic concepts of the mechanisms of carcinogenesis and to begin applying these concepts to research problems.

Frequency of offering: Every Fall
Prerequisite: None

Classification: Major Compulsory

Advanced Biochemistry

Course Code		CHM6024
Credits	Class hr	Lab hr
3	3	0

Biochemistry is the branch of science that explores the chemical processes within and related to living organisms. It is a laboratory based science that brings together biology and chemistry. By using chemical knowledge and techniques, biochemists can understand and solve biological problems. Biochemistry focuses on processes happening at a molecular level. It focuses on what's happening inside our cells, studying components like proteins, lipids and organelles. It also looks at how cells communicate with each other, for example during growth or fighting illness. Biochemists need to understand how the structure of a molecule relates to its function, allowing them to predict how molecules will interact. Biochemistry covers a range of scientific disciplines, including genetics, microbiology, forensics, plant science and medicine. Because of its breadth, biochemistry is very important and advances in this field of science over the past 100 years have been staggering. It's a very exciting time to be part of this fascinating area of study. In addition Biochemistry aims to answer many questions arising from molecular cellular biology by using tools developed within chemical synthesis. Therefore, the ultimate goal of this course is to introduce students to the concepts of the molecular and cellular biochemical process in living things to begin applying these concepts to research problems.

Frequency of offering: Every Fall
Prerequisite: None

HANYANG UNIVERSITY

Department of
Mathematics

Classification: Major Elective

Scientific Computing

Course Code		MAT8037
Credits	Class hr	Lab hr
3	3	0

In this course we will concentrate on Numerical Linear Algebra. Students will study the solutions of linear systems of equations, least square problems, eigenvalue problems, and singular value problems. Techniques for dense, sparse and structured problems will be covered. Students should still come to appreciate many state-of-the-art techniques and recognize when to consider applying them. Students will also learn basic principles applicable to a variety of numerical problems and learn how to apply them. These principles include (1) matrix factorizations, (2) perturbation theory and condition numbers, (3) effect of roundoff on algorithms, including properties of floating point arithmetic, (4) analyzing the speed of an algorithm, and (5) choosing the best algorithm for the mathematical structure of your problem.

Frequency of offering: Every Other Spring
Prerequisite: Undergraduate Numerical Analysis, Linear Algebra, Differential Equations

Classification: Major Elective

Algebra 1

Course Code		MAT8078
Credits	Class hr	Lab hr
3	3	0

This course is for the first year graduate students in mathematics. In this course, students study advanced topics on groups, rings, modules, representations, polynomials, commutative algebra, homological algebra, and multilinear algebra. Sylow theory, Galois Theory, the fundamental theorem of finitely generated abelian groups, free groups, commutative rings, localization, principal and factorial rings, Notherian rings, free modules, group rings, direct and inverse limits, and some advanced theory of ideals from the theory of rings and modules are introduced. This course is for students who have mastered the basics of Linear Algebra and undergraduate abstract algebra.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Complex Analysis

Course Code		MAT9025
Credits	Class hr	Lab hr
3	3	0

Complex Analysis is an essential and fundamental subject which has something for all mathematicians. In addition to having applications to other parts of analysis, it can claim to be an ancestor of many areas of mathematics such as algebra theory and statistics. In this course, students enter the intriguing world of complex analysis. From the first theorems on, the elegance and sweep of the results is evident. The starting point of this course is the simple idea of extending a function initially given for real values of the argument to one that is defined when the argument is complex. In this course, students enter the intriguing world of complex analysis. From there, students proceed to the main properties of holomorphic functions, whose proofs are generally short and quite illuminating: the Cauchy theorems, residues, analytic continuation, and the argument principle.

Frequency of offering: Every Fall
Prerequisite: None

Classification: Major Elective

Real Analysis

Course Code		MAT9062
Credits	Class hr	Lab hr
3	3	0

The general theory of measure and integration was introduced in the early twentieth century. Now, this theory is indispensable in remarkably diverse areas of mathematics, physics, and economics. In particular, probability theory, partial differential equations, functional analysis, harmonic analysis, dynamical systems and stochastic calculus, and etc. Real Analysis is an essential and fundamental subject for students who desire to have solid understanding of the Lebesgue measure and integration. This course will give an introduction to classical theory of functions, Lebesgue measures and Lebesgue integration. It is the basis of integration theory and provides the conceptual framework for probability. We will cover the following contents: differentiation and bounded variation, absolute continuity and convex functions, classical Banach spaces, approximation and bounded linear functionals, measure spaces, measurable functions and integration, signed measures, Radon-Nikodym theorem and Riesz representation theorem, outer measure and measurability, Lebesgue-Stieltjes integral, product measures and Hahn and Lebesgue decomposition.

Frequency of offering: Every Other Fall
Prerequisite: None

HANYANG UNIVERSITY

Department of **Physics**

Classification: Major Elective

Experimental High Energy Physics

Course Code	PHY6046	
Credits	Class hr	Lab hr
3	3	0

Goal of this class is to understand the fundamentals of experimental high energy physics. Class will focus on the basic theoretical concept of modern particle physics relating with experimental phenomenology. This will cover the overview of the Standard Model physics, that explains our nature the most successfully so far, both experiment and underlying physics. Modern particle detectors being used in collider physics will be introduced briefly to understand how the fundamental particles can be discovered as well. The latest experimental results including the observation of the Higgs boson predicted in 1964 as well as potential discovery scenarios beyond the Standard Model will be discussed during the class. By the end of this class, students should have a good understanding of experimental aspects of particle physics.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Data Analysis Based on Accelerator Experiment

Course Code	PHY6050	
Credits	Class hr	Lab hr
3	3	0

The Large Hadron Collider (LHC) at CERN produces about 30 petabytes of data from proton collisions annually. Each collision contains the decay products from the fundamental particles (e.g. Higgs boson) that can explain the origin of the mass or W and Z boson that mediate the week interaction which is one of the four interactions in nature. New physics can also appear from the data set of these collisions. It is challenging to shift and analyze the data for interesting physics events. To deal with this amount of data, the worldwide LHC computing Grid should be used. In the data analysis, to test the hypothesis of new physics or find parameters from the fit, statistical analysis method should be introduced as well. During this course, students will learn how to choose the interesting collisions events and perform the statistical analysis with the data.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Surface Physics

Course Code		PHY6062
Credits	Class hr	Lab hr
3	3	0

The properties of surfaces of solids and their interfaces are of great significance not only because of the scientific understanding but because of their applications in the industry. The electrical and magnetic properties of the surface of a solid can be quite different from those of the bulk: manufacturing a thin-film device will require knowledge of the various properties of interfaces; chemical reaction at the surface should be examined to understand the catalytic reaction. This lecture will act as a bridge between the basic notions of physics (solid state physics and statistical mechanics) and research. Structure of surfaces, basic techniques including vacuum, application of thermal and statistical physics, adsorption, and vibration at surfaces, electronic structure of surfaces, surface magnetism, and diffusion at surfaces will be covered.

Frequency of offering: Every Other Spring
Prerequisite: Quantum Mechanics (Undergraduate)

Classification: Major Elective

Solid State Physics 1

Course Code		PHY9039
Credits	Class hr	Lab hr
3	3	0

Many properties of solids can be understood with quantum mechanics and thermal physics: the electrical conduction and the temperature dependence of specific heat were successfully explained by using early quantum theory. As a part of the two-semester lecture, this course introduces such basic concepts as crystalline structure, reciprocal lattice, free-electron theory, one-electron approximation, band theory, excitons, plasmons, screening, and adiabatic principle. The lectures will be theory-oriented, but relating mathematics will not be immensely demanding. Students are required to know some basic notions of wave aspects of quantum theory.

Frequency of offering: Every Other Spring
Prerequisite: Quantum Mechanics (Undergraduate)

Classification: Major Elective

Solid State Physics 2

Course Code		PHY9040
Credits	Class hr	Lab hr
3	3	0

As a second part of Solid State Physics, this course introduces basic notions of lattice dynamics, scattering of particles by crystals, optical and transport properties, electron gas in magnetic fields, magnetic properties, and superconductivity. Emphasis will not be placed on topics on semiconductors because there is a lecture exclusively on semiconductors (PHY8040). Although this course is a continuation of Solid State Physics 1, the latter is not a prerequisite if students are acquainted with such concepts as reciprocal lattice and band theory.

Frequency of offering: Every Other Fall
Prerequisite: Quantum Mechanics (Undergraduate)

Classification: Major Elective

Quantum Informatics

Course Code		PHY9058
Credits	Class hr	Lab hr
3	3	0

Quantum informatics is the field that unifies the quantum physics and the information science. It has meanings of two folds: One is that information is processed on quantum systems as utilizing quantum-mechanical laws such as superposition and entanglement that no classical information processing can ever simulate. The other is that quantum physics is viewed in a perspective of information theory, that no physical theories have been ever tried. Quantum informatics applies to information communication and computation, and also considers their physical realization on quantum systems. This subject includes principle notions, methods, and applications of quantum information. More explicitly, it includes discussions on no-cloning theorem, quantum teleportation, quantum cryptography, quantum communication, quantum computation, superposition and entanglement.

Frequency of offering: Every Other Spring
Prerequisite: None

Classification: Major Elective

Waveguide Optics

Course Code	PHY9067	
Credits	Class hr	Lab hr
3	3	0

In this class, fundamental principle of optical waveguides will be discussed. The waveguide theory to analyze the effective indices of optical waveguides depending on operating wavelength will be investigated to understand and design various optical waveguides. The electromagnetic principle will be applied to analyze wave propagation in the optical waveguide and understand the basic behavior of light in the waveguide qualitatively. Basic dispersion concepts and the waveguide manifestations will be developed. Field analysis methods for single-mode and multimode waveguide will be studied. The coupled mode theory will be studied to design and fabricate the practical optical devices and components. It includes study and discussion on the coupled-mode theory, optical waveguides, phase matching, dispersion, arrayed waveguide, grating etc. Transmission and reflection characteristics of light after mode-coupling in isotropic and anisotropic will be studied.

Frequency of offering: Every Other Spring
Prerequisite: Electromagnetics

Classification: Major Elective

Nanophotonics

Course Code	PHY9068	
Credits	Class hr	Lab hr
3	3	0

An ultimate goal of nanophtonics may be addressed by the theories of how to generate, confine, and guide photonic modes on a diffraction-limited subwavelength scale. One of the potential approaches to realize nanophotonic systems, we investigate the theoretical backgrounds on surface plasmon photonics. Surface plasmon is a kind of polaritons composed of collective free-electron oscillations and photonic modes. We will discuss analytic expressions on the theories of how to define surface-plasmon polaritons excited on many different kinds of boundaries between dielectrics and metals, and will focus on identifying potentials of surface plasmons for future nanophotonics. The topics in this course include optical properties of materials-dielectrics and metals, dispersion relation of single metal-dielectric interfaces, surface plasmon Excitation, EM energy density of surface plasmons, localized surface plasmons: Rayleigh & Mie scattering, dispersion relation of metal nanorods and nanotips, dispersion relation of multilayer metallic thin films and IMI structures, insulator-Metal-Insulator SPP waveguides, metal-Insulator-Metal Plasmonic waveguides, and Surface-plasmon mediated light sources

Frequency of offering: Every Other Spring
Prerequisite: None