

# HANYANG UNIVERSITY COURSE CATALOG

GRADUATE COURSES IN ENGLISH



HANYANG UNIVERSITY

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# GREETINGS

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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**

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**HANYANG UNIVERSITY**

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Hanyang University  
Seoul Campus

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Architecture**



Classification: Major Elective

## **Architectural Tectonics (Architectural Structure System)**

Course Code	ARD9082	
Credits	Class hr	Lab hr
3	3	0

With the rapidly expanding scope and complexity of the architectural practice, the architect is faced with today, more so than at any other time in history, with the staggering problem of assimilating the many scientific and technological advances into the art of architecture. One main aspect of this intricate problem is the integration of creative, imaginative and economically pure structure into the design process. This course starts with the investigation, which is the basic principles of architectural structures, including the influence of geometric, sectional, and material properties. With these backgrounds, the course will explore the design and science of logical form making examined through structural system, materiality, and digital tools. Then the point of departure is defining accumulative/repetitive sequence of fundamental topics and problems in design geometry. The iteration will cultivate a certain objective approach to form that explores the application of structural system in functional design as well as engineered design. Thematically, the course fosters an integrated understanding of topics such as architectural design (Geometry/form) and structural system. Moreover, the course will foster a commitment to craftsmanship, cooperation, and invention, developing a fundamental knowledge base of materials and integrating a full range of design and production skills to prepare students to work creatively and responsibly within an increasingly networked profession.

**Frequency of offering:** Every Fall

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Automotive Engineering**



Classification: Major Elective

## Vehicle Structure Optimum Design

Course Code	AUE8026	
Credits	Class hr	Lab hr
3	3	0

Manufacturers of modern vehicle are demanding more lightweight and more durable structures. Structural integrity is a major consideration of next generation vehicle. For a vehicle to economically achieve its design specification and satisfy safety regulations, a number of structural challenges must be overcome. This course provides engineers with modern concepts of optimal design of structures. The objective of the course is to present tools and methodologies for performing vehicle structure optimization in a multidisciplinary design context. Focus will be on all three aspects of the problem: vehicle structures, optimization concepts, and simulation methods. Analytical and numerical methods are developed and their applications discussed. It is required to propose creative ideas for definition of optimization problem for lightweight structure and solve the optimization problem to learn applicability of optimization technologies to practical vehicle design.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Optimization Techniques

Classification: Major Elective

## Advanced Mechanical Behavior of Materials

Course Code	AUE8028	
Credits	Class hr	Lab hr
3	3	0

In order to understand the materials behavior coupled with corresponding microstructural characteristics during the deformation and failure processes, some of the following knowledge are essentially required. Firstly, material science based characteristics for example, microstructure factors, atomic structure, dislocation and etc. Secondly, strength of materials related topics such as elasticity, plasticity and yield theory. Finally, further deformation-failure mechanics include creep, fracture, and damage processes. Advanced engineering mathematics (i.e., tensor theory) is also required for the analysis of mechanics. In the viewpoint of design technology for engineering components and/or structures such as aerospace, automotive and many other applications, designers or manufacturers require knowledge related to some of the following issues; product properties, material status together with adequate deformation and failure mechanisms. This course, therefore aims to achieve the above topics for the fields of mechanics/materials engineering graduate students.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Optimization Techniques

Course Code	GAF8002	
Credits	Class hr	Lab hr
3	3	0

This course aims to provide students with concepts and mathematical foundations of the optimization theory and its application to practice. The lectures cover modeling, formulation, and analysis using optimization concepts and principles, linear and nonlinear models, optimality conditions, and numerical methods. Students practice simple application of optimization to traditional engineering designs. Based on the understanding of Kraush-Khun-Tucker optimality conditions, mathematical concepts for unconstrained and constrained optimizations are studied. In recent years, numerical optimization methods have matured into a powerful and efficient design tool for a wide variety of engineering applications. This course provides a broad overview of the concept of numerical optimization and the associated fundamental mathematics and algorithms. Also, a variety of practical applications are presented to indicate the breadth of optimum design problems that can be resolved with these optimization tools.

**Frequency of offering:** Every Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Bioengineering**



Classification: Major Elective

**Advanced Biochemistry 2**

Course Code	<b>DBE0006</b>	
Credits	Class hr	Lab hr
3	3	0

The course will focus on the fundamental principles in eukaryotic transcription and posttranscriptional regulation. Students will gain an in-depth knowledge of transcription activators, chromatin structure, and post-transcriptional modification. Eukaryotic gene expression is regulated by transcription factors, change of chromatin structure, mRNA stability, and protein stability. The knowledge of these gene regulations will be useful for clinical applications of genes such as gene therapy. The topics in this class are as follows: (1) Eukaryotic RNA polymerases and their promoters, (2) General transcription factors-Class II factors, (3) Class I and III factors, (4) Structures of the DNA-binding motifs of activators, (5) Functions of activators and Interaction among activators, (6) Regulation of transcription factors, (7) Histones and nucleosomes, (8) Chromatin structure and gene activity, (9) Capping and polyadenylation, (10) Ribosomal RNA processing, (11) Trans-splicing and RNA editing, and (12) Post-transcriptional regulation.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

**Therapeutic Genetics**

Course Code	<b>DBE0016</b>	
Credits	Class hr	Lab hr
3	3	0

The course will focus on the therapeutic genes, which are used for gene therapy. Therapeutic genes should be carefully selected, cloned, and modified for a disease. Also, the therapeutic gene should be carefully modulated to increase therapeutic efficacy and avoid side effects. In addition, non-viral gene delivery vectors are introduced in this class. The design, synthesis, and applications of non-viral vectors for various diseases will be discussed with many examples. The students will gain in-depth knowledge about non-viral vector mediated gene therapy. Therefore, topics in this class are as follows: (1) Therapeutic genes for various diseases, (2) How to clone therapeutic genes, (3) How to modify therapeutic genes, (4) Gene expression: transcriptional targeting, translational regulation, posttranslational regulation, (5) targeted vectors: non-viral vectors, and (6) Applications of therapeutic genes to various diseases.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

## Drug Delivery System

Course Code	DBE0012	
Credits	Class hr	Lab hr
3	3	0

At present, there are 30 main drug delivery products on the market. The total annual income for drug delivery products is approximately US\$55 billion with an annual growth of 15%. Current developments are focused on targeted delivery in which the drug is only active in the target area of the body (for example, in cancerous, ischemic, and degenerative tissues), and controlled release formulations in which the drug is released over a period of time in a controlled manner from a formulation, thereby improving efficacy and safety. Macromolecular and biomedical polymer science have evolved significantly over the past decades, with remarkable advances in many areas such as polymeric drugs, self-assembly systems, implant materials, drug delivery systems and controlled drug release. With a rapid progress in biotechnology, a variety of endogenous macromolecular substances have become a novel class of therapeutic agent. This lecture will focus on the development of delivery systems for macromolecular drugs based on macromolecular carriers. Macromolecular drug delivery products can offer (1) localized delivery of drug, (2) controlled delivery of drug, and (3) stabilization of the drug. Despite the obvious promise of new medicines (e.g. proteins, genes, liposomes, etc.), their delivery to target sites presents distinct and generic barriers to overcome. Although there are important problems to address in the therapeutic use of macromolecules including stability in the biological milieu, entry into cells, and biodistribution in the body, macromolecules are inherently more information-rich than small molecules and therefore potentially have greater specificity as drugs. Upon completion of this lecture, the students will know issues associated with application of biomedical macromolecules, synthesis and characterization, cellular transport, biocompatibility, macromolecular-drug conjugate, macromolecular drug carriers and future trend.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

**Biopharmaceutical Delivery**

Course Code	DBE0020	
Credits	Class hr	Lab hr
3	3	0

Biotechnology has produced highly potential new molecules such as peptides, proteins and nucleic acids. Biopharmaceuticals, especially protein drugs are classified into 5 categories such as enzymes, hormones, cytokines, vaccines and monoclonal antibodies. Due to their sensitivity to chemical and enzymatic hydrolysis as well as a poor cellular uptake, their in vivo bioavailability remains very low. This lecture will cover basic concepts on mechanisms of degradation and stabilization of biopharmaceuticals, cellular mechanism of action, rationale of novel drug formulations and delivery system, introduction to polymer in biopharmaceutical delivery, and polymeric carriers. Upon completion of these lectures, students will know issues associated with the biochemical mechanisms, stability, use and dispensing of biotechnology derived drugs, including current and anticipated applications.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Compulsory

**Applied Biochemistry Design**

Course Code	DBE0030	
Credits	Class hr	Lab hr
3	3	0

One-on-one research discussion and presentation will be performed focused on recently published articles related to advanced techniques for biochemistry & cell biology research. The topics include DNA recombinant technology, animal cell culture, gene expression, animal experiments and protein purification, etc. Students should design and perform their own research in the laboratory. This course will cover basic principles, cell culture techniques, transfection, centrifugation, molecular biology, bioinformatics and basic techniques, recombinant DNA and genetic analysis, immunochemical techniques, protein structure, purification, characterization and function analysis, electrophoretic techniques, chromatographic techniques, and radioisotope techniques.

**Frequency of offering:** Every Other Spring**Prerequisite:** General Biochemistry I & II

Classification: Major Elective

## Advanced Diabetes Therapy 1

Course Code		DBE0037
Credits	Class hr	Lab hr
3	3	0

In this course, we will study about the causing reasons and therapies of diabetes mellitus. First, we will research the genetic and environmental reasons to induce the diabetes mellitus. Then we will move to the specific therapeutic strategies such as the drug delivery system (DDS), gene therapy and cell therapy for intensive discussion. Finally, we will carry out the student presentations to understanding the recent research related to the diabetes therapy. "Principles of Diabetes Mellitus, Second Edition" is an important update to the comprehensive textbook first published in 2002 and reissued in 2004. It is written for physicians of all specialties who, on a daily basis, deal with an illness which has reached epidemic proportions. The book is also intended for medical students and investigators of all aspects of diabetes. The last five years have witnessed major developments in our understanding of diabetes and in therapeutic approaches to this disease. Thus, in addition to updating all chapters, the authors added eight new chapters to the second edition. "Principles of Diabetes Mellitus, Second Edition" covers diabetes in all of its aspects – genetics, epidemiology, pathophysiology, clinical manifestations, therapy and prevention.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Physiology, Biomaterials

Classification: Major Elective

## Advanced Diabetes Therapy 2

Course Code		DBE0038
Credits	Class hr	Lab hr
3	3	0

In this course, we will study about the causing reasons and therapies of diabetes mellitus. First, we will research the genetic and environmental reasons to induce the diabetes mellitus. Then, we will move to the specific therapeutic strategies such as the drug delivery system (DDS), gene therapy and cell therapy for intensive discussion. Finally, we will carry out the student presentations to understand the recent research related to the diabetes therapy. "Principles of Diabetes Mellitus, Second Edition" is an important update to the comprehensive textbook first published in 2002 and reissued in 2004. It is written for physicians of all specialties who, on a daily basis, deal with an illness which has reached epidemic proportions. The book is also intended for medical students and investigators of all aspects of diabetes. The last five years have witnessed major developments in our understanding of diabetes and in therapeutic approaches to this disease. Thus, in addition to updating all chapters, the authors added eight new chapters to the second edition. "Principles of Diabetes Mellitus, Second Edition" covers diabetes in all of its aspects – genetics, epidemiology, pathophysiology, clinical manifestations, therapy and prevention.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Physiology, Biomaterials

Classification: Major Elective

**Advanced Nanobioengineering 1**

Course Code		<b>DBE0039</b>
Credits	Class hr	Lab hr
3	3	0

We will study about the merged technology between nanoscience and bioscience and also discuss about the Surface system, fabrication of DNA-based nanostructure, fabrication of protein-based nanostructure, and the nano-analytical system. Then, we will present on the recent nanobio-based research related to the cutting edge technology: Multiplexed detection using quantum dots, Medical diagnostics of quantum dot-based protein micro- and nanoarrays, Imaging and tracking of viruses using quantum dots, Nanomaterials for radiation therapy, Prospects of semiconductor quantum dots for imaging and photodynamic therapy of cancer, Impact of nanoparticle sterilization on analytical characterization, and endotoxin and engineered nanomaterials. All registered graduate students will present each topic, which is adapted from the literature. Then the lecturer and all registered students will discuss about the presentation topic in detail. Later, all students will hand out the final reports.

**Frequency of offering:** Every Other Spring**Prerequisite:** Physiology, Biomaterials.

Classification: Major Elective

**Advanced Nanobioengineering 2**

Course Code		<b>DBE0040</b>
Credits	Class hr	Lab hr
3	3	0

We will study about the merged technology between nanoscience and bioscience and also discuss about the Surface system, fabrication of DNA-based nanostructure, fabrication of protein-based nanostructure, and the nano-analytical system. Then, we will present on the recent nanobio-based research related to the cutting edge technology: Multiplexed detection using quantum dots, Medical diagnostics of quantum dot-based protein micro- and nanoarrays, Imaging and tracking of viruses using quantum dots, Nanomaterials for radiation therapy, Prospects of semiconductor quantum dots for imaging and photodynamic therapy of cancer, Impact of nanoparticle sterilization on analytical characterization, and endotoxin and engineered nanomaterials. All registered graduate students will present each topic, which is adapted from the literature. Then the lecturer and all registered students will discuss about the presentation topic in detail. Later, all students will hand out the final reports.

**Frequency of offering:** Every Other Fall**Prerequisite:** Physiology, Biomaterials

Classification: Major Elective

## Live Cell Imaging

Course Code	DBE9002	
Credits	Class hr	Lab hr
3	3	0

Many of the remarkable images and analyses on the dynamic properties of molecules in living cells described in this course are from technical advances of the early 1970s. This was the period when commercially available epifluorescence microscopes equipped with efficient dichroic filter systems were introduced. The detection and approaches to live cell imaging are introduced in this course with epifluorescence microscopes, application with antibody, fluorescence in situ hybridization (FISH), genetic engineering, and drug delivery system. Lecture topics include: fluorescent protein tracking and detection, constructing and expressing GFP fusion proteins, viral vectors for introduction of GFP, gene delivery by direct injection and facilitation of expression by mechanical stretch, microinjection of fluorophore-labeled proteins, CCD cameras for fluorescence imaging of living cells, FRET and fluorescence lifetime imaging microscopy, monitoring protein dynamics using FRET-based biosensors, application of light-directed activation of caged biomolecules and CALI to problems in cell motility and photoactivation-based labeling, and in vivo tracking of RNA molecules in the nucleus

**Frequency of offering:** Every Other Spring

**Prerequisite:** Biomaterials, Cell Biology

Classification: Major Elective

## Immunological Analysis Techniques

Course Code	DBE9003	
Credits	Class hr	Lab hr
3	3	0

This course is open to graduate student who have studied basic immunology, cell biology or related subjects. The course will focus on the experimental approaches to detect immune response as they apply to inflammation, infection, tumour recognition, autoimmune diseases, immunodeficiency, cancer or hypersensitivity. Students will review basic concept of immunology from text book and application of immunological techniques for their research projects. Lectures will be on subjects in immunology text book and immunological analysis will be covered from current published papers. Students will be required to present an interesting paper related to their research field in the class from current published papers in major journals. Our goal is to understand immunological analysis for therapeutic reagents such as biomaterials, nano-materials, stem cells etc.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Molecular/Cell Biology, Basic Immunology

Classification: Major Elective

## Ex Vivo Cell Therapy

Course Code	DBE9004	
Credits	Class hr	Lab hr
3	3	0

The field of ex vivo cell therapy was born out of the necessity to manipulate the cellular constituents of hematopoietic cell grafts, to remove malignant cells and to increase the number of stem cells. Ex vivo cell therapy provides the opportunity to manipulate the immune system to reduce the graft-versus-host reaction and autoimmune cells while augmenting the graft-versus-tumor effect and antiviral immunity. The goal of this course will be focused on strategies that require cell selection, expansion, and gene transfer. This field of research will lead to better therapy for malignant disease, disseminated viral infections, autoimmune diseases, and genetic disorders. Lecture topics include: oxygen carriers based on nanobiotechnology, nanobiotechnologic therapeutic that transports oxygen and remove oxygen radicals: for stroke, hemorrhagic shock and related conditions, nanotechnology-based artificial red blood cells (RBCs), and use of enzyme artificial cells for genetic enzyme defects that increase systemic substrates to toxic levels.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Cell Biology, Biomaterials

Classification: Major Elective

## Systems Biology Design

Course Code	DBE9006	
Credits	Class hr	Lab hr
3	3	0

The present course provides Ph.D. level graduate students multiple engineering approaches to develop novel therapeutic and diagnostic methods based on understanding of physiological phenomenon related to normal and abnormal conditions of biological systems. As basic principles of biological system, the topics include DNA recombinant technology, animal cell culture, gene expression, animal experiments and protein purification. In particular, this course describes the mechanisms and architecture of biological systems to formulate and design biomimetic structure, and evaluation techniques for interactions between biomimetic systems and surrounding cell and/or tissues. Also the topics on advanced level in mechanism and applications of biosensor, imaging techniques for treatment of patients, and microfabrication-based technology on development of medical devices will be presented. During the class, the students are encouraged to make teams for discussion on specific current problems in the related fields.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Biology, Molecular Biology, Biochemistry

Classification: Major Elective

## Advanced Immunology

Course Code	<b>DEB0018</b>	
Credits	Class hr	Lab hr
3	3	0

This is a graduate level introduction to immunology and is intended for students who did/did not enroll in an undergraduate immunology course. However students must have taken Cell Biology and Molecular Biology. The course will focus on the mechanisms which govern the immune response and will cover the cells, organs and molecules that mediate the innate and adaptive aspects of the immune system as they apply to infection, tumor recognition, autoimmune diseases, immunodeficiency, cancer and hypersensitivity. Emphasis will be placed on a thorough understanding of cell and molecular processes as they apply to individual host defense mechanisms and the cooperative functioning of multiple defense mechanisms. The intention of this course is also to train the students in reading and evaluating research articles which are published in peer-reviewed journals. Lectures will be on broad topic areas in immunology and discussions will be on representative recent papers.

**Frequency of offering:** Every Fall

**Prerequisite:** Molecular Biology, Cell Biology

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Department of  
**Biomedical Engineering**



Classification: Major Elective

## Advanced Biomimetic Engineering

Course Code	BME6006	
Credits	Class hr	Lab hr
3	3	0

Biomimetic technology is useful to human's life by investigation of creatures of nature, and all creatures act as its model. Understanding of creatures of nature suggests a solution to a problem which is a limitation of present biotechnology. It is possible that nano-biomimetic technology is applied directly to its application fields by mimicry of basic concept of nature. For examples, spider web silk is as strong as the Kevlar used in bulletproof vests. Engineers could in principle use such a material, if it could be reengineered to have a long enough life, for suspension bridge cables, artificial ligaments for medicine, and other purposes. By adapting mechanisms and capabilities from nature, scientific approaches have helped humans understand related phenomena and associated principles in order to engineer devices and improve their capability. Here in this lecture, recently research as well as future direction of biologically inspired technologies will be discussed.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Advanced NanoBio Engineering

Course Code	BME6003	
Credits	Class hr	Lab hr
3	3	0

Nanobio technology, the cooperative field of medical science and engineering, has received much attention as the brilliant technology for the solution of public health and the research and development of medical technology from the nano-engineering technology. The principles of the human nature can be applied for the solution of engineering technology problems. Additionally, applications of nanobio technology are extremely widespread. The nanobio technology is much more commonplace in that it simply provides more tools for the study of biology. By using the diversity of micro and nanostructure realized by newly developed technologies, the application for industrial and development of smart artificial structure can be achieved, which was not possible through the traditional technology. In this class, overall contents of state of the art and R&D of nanobio technology will be discussed.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

**Biomimetic System**

Course Code		<b>GHY9065</b>
Credits	Class hr	Lab hr
3	3	0

Throughout the history, humans have sought to mimic the appearance, functionality, and longevity, as well as the cognitive and adaptive processes of biological creatures. This desire to mimic nature also includes mimicking human characteristics. The field of biologically mimetic technology continues to develop engineered system that exhibits the appearance and behavior of biological system. Biomimetic is a field with fascinating historical precursors and exciting possibilities for the future. In this course, an overview of ideas, tool, artifact, and applications associated with the field of biomimetic will be presented and discussed. One of the key issues in class is to design the biomimetic system that could in principle be applied in many fields. Because of the complexity of biological systems, the number of features that might be imitated is large. Biomimetic applications are at various stages of development from technologies that might become commercially usable to prototypes.

**Frequency of offering:** Every Fall**Prerequisite:** None

Classification: Major Elective

**Advanced Biomaterial Engineering**

Course Code		<b>BME6007</b>
Credits	Class hr	Lab hr
3	3	0

A chemomechanical system is the system that transforms chemical free energy to mechanical motion when stimulated by a changes in its surroundings. The polymer materials that are capable of executing mechanical work, such as contraction and expansion, as well as bending, using the chemical free energy of polymer under the electrical stimulus are called electroactive polymer. The flexible behavior, elasticity on a motion, light weight, and capability of miniaturization of EAP make the masaexcellent candidate for the application of artificial muscle. Since there are many advantages for the application, it is also expected to be applied into the new technical fields such as biosensor, drug delivery system and robotics. Here in this class, recently research result and its future direction of electroactive polymer as a biomaterial will be discussed.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## Optical Diagnostics Applications

Course Code	<b>BME6014</b>	
Credits	Class hr	Lab hr
3	3	0

Optical diagnostics is an emerging multidisciplinary field using advanced optical imaging techniques and optical signal processing methods to apply the techniques for medical diagnosis. Optical imaging methods have become essential clinical tools for diagnosing various diseases in many medical fields, including ophthalmology, dermatology, gastroenterology, and cardiology. By providing structural and molecular images of biological tissues with an unprecedented high spatial resolution, optical images are used to interrogate biological and chemical changes of the tissue at the cellular level. Especially, some optical imaging techniques, such as confocal microscopy and optical coherence tomography, provide images from living patients in a minimally or non-invasive ways. In this course, recently developed optical techniques for diagnosis of various diseases will be introduced. Especially, applications using miniaturized endoscopic imaging probes and imaging catheters in cardiovascular disease and esophageal disease will be discussed.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Optical Signal Analysis

Course Code	<b>BME6040</b>	
Credits	Class hr	Lab hr
3	3	0

Optical imaging utilizes light to interrogate biological features of live cells and to look inside the body non-invasively. Optical imaging techniques have become essential tools for biomedical research and medical diagnostics. Data acquisition, processing, and analysis of various optical imaging systems, such as confocal microscopy and optical coherence tomography, are very important in the field of biomedical optics. In this course, optical data acquisition and image processing methods will be introduced. Through this course, the students will learn basic knowledges to obtain and reconstruct structural, biological, and chemical information from the biological tissue using optical signals. Also, based on the image reconstruction and processing algorithms, the students will learn how to extract meaningful information from the optical signals and images.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Chemical Engineering**



Classification: Research Selection

## Guidance of Research Thesis for Chemical Engineering

Course Code		CHE6013
Credits	Class hr	Lab hr
3	3	0

There are often barriers for scientists to effectively communicate their research. This course will give graduate students the ability to prepare and communicate poster presentations as well as oral presentation to meet any audience's needs and backgrounds while presenting their research in English. The course will also outline the key points necessary for preparation and writing of a high quality research thesis, which will provide essential skills that may carry over into becoming more effective authors of journal and conference publications. In addition to increasing the student's ability to effectively communicate chemical engineering research in both writing and presentations, the students will learn skills to capture the attention of the audience, learn how to handle difficult questions from the audience, and understand the capabilities of different audiences.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Selection

## Special Topics in Chemical Biology

Course Code		CHE7013
Credits	Class hr	Lab hr
3	3	0

The chemical modification of biological systems (ie. cells, protein, and DNA) has allowed significant progress in chemical sensor research, the discovery of new pharmaceuticals, advances in stereo-selective chemical reactions, and the realization of new energy systems. This course will give graduate students the knowledge of basic as well as advanced techniques for the chemical modification of biological systems with in-depth discussion on the reactions, necessary requirements, and limitations. After taking this class, students will newly gain the skill of being able to effectively change the chemical functionality, surface, or create linkage/attachment sites on any bio-polymeric system, even if they have had no prior experience in biology. The course goal is to give graduate students the knowledge and skills to make chemical modifications to cells, proteins/enzymes, DNA, sugars, and lipids. The students will gain these valuable skills by learning basic bio-conjugation reactions, modern methods for incorporating unique chemical tags into biopolymers, and enzymatic means for creating bio-orthogonal modifications.

**Frequency of offering:** Every Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Civil and  
Environmental  
Engineering**



Classification: Major Elective

## Advanced Computational Mechanics for Structural Engineering

Course Code	CEE8009	
Credits	Class hr	Lab hr
3	3	0

This course deals with the nonlinear theory of continuum mechanics and the nonlinear computational methods. Geometry nonlinear theories such as kinematics of large deformation and large rotation are introduced with nonlinear finite element techniques, the Newton-Rhapson method, and the Gauss-Seidal method. In addition to geometry nonlinear theories, material nonlinear theories are dealt with a classical theory of constitutive equations for elastoplastic materials. This course aims to understand classical nonlinear theories and schematic procedure of nonlinear numerical programs. Therefore, this course provides many numerical techniques in order to solve geometry and material nonlinear problems. Students can obtain technical skills to perform ABAQUS, which is a commercial nonlinear program, and to make not only a complex geometry model but also an elastoplastic model using UMAT or VUMAT subroutines library of ABAQUS.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Advanced Mathematics, Finite Element Method

Classification: Major Elective

## Analysis of Plates and Shells

Course Code	CEE8012	
Credits	Class hr	Lab hr
3	3	0

The primary objective of this course is to learn advanced methods in theory of plates and shells pertaining to analysis of solids. The focus will be on the use of general relationships in the solution of mechanics problems. The topics of the course are the introduction of the classical structural mechanics approximations of membrane, plastic and shell theories, use of energy formulations to demonstrate the consistent derivation of approximate boundary conditions and edge effects, and the approximation of the classical formulations using numerical approximation techniques. This course will allow students to increase their abilities (1) to apply knowledge of mathematics, science and engineering related to plate and shell theory, (2) to identify, formulate, and solve theoretical problems with structural plate and shell elements, and (3) to use finite element methods in plate and shell analysis and to use plate and shell theory for the verification of finite element results.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

**Nonlinear Wave Theory**

Course Code		CEE8018
Credits	Class hr	Lab hr
3	3	0

Waves are present all around us, the most obvious examples being sound, light and water waves. The objective of this course is to study the waves of finite amplitude in a waterbody. This course starts with the review of the linear wave theory. This course aims to provide an introduction to linear and nonlinear wave theories, and to give students a clear understanding of the properties of nonlinear waves and the relevance of these to physical systems, such as higher harmonic generation, wave set-up, rip currents, longshore currents, and stem waves. The Stokes and Boussinesq wave theories will be studied to deal with nonlinear wave problems. Some two-dimensional and three-dimensional numerical models will be introduced to solve practical problems including nonlinear wave transformations in a shallow water, harbor resonance, and harbor tranquility, etc.

**Frequency of offering:** Every Other Spring**Prerequisite:** Fluid Mechanics and Coastal Engineering (Undergraduate)

Classification: Major Elective

**Long Waves and Disaster Prevention Engineering**

Course Code		CEE8019
Credits	Class hr	Lab hr
3	3	0

In the coastal area, the external conditions such as the rise of the mean sea level by global warming and the aging coastal facilities become severe and the risk has been increased. This course discusses to evaluate the risk of the flood and the inundation by storm surge and tsunami in the highly developed coastal area. This course introduces the brief review of linear wave theory and hydrodynamics. The generation, propagation, and inundation mechanisms for storm surges, tsunamis, and meteo-tsunamis will be studied in detail. The governing equations to deal with those phenomena will be derived. The numerical methods are then introduced to simulate those long waves. The preparation of input data such as wind speed for storm surges and the initial ground motion for tsunamis is introduced. In the last part of this course, various applications of the theory and the numerical simulation to the practical problems will be introduced.

**Frequency of offering:** Every Other Spring**Prerequisite:** Fluid Mechanics or Coastal Engineering (Undergraduate)

Classification: Major Elective

## Dynamics of Structures

Course Code		CIE8008
Credits	Class hr	Lab hr
3	3	0

Dynamics of structures is a type of structural analysis which covers the behavior of structures subjected to dynamic loads such as people, wind, waves, traffic, earthquakes, and blasts. This course introduces the basic concepts of the dynamic response of structures subjected to these loads, as well as the practical applications of such concepts in reality. This course begins with the derivation of the basic equations of motion for an ideal single degree-of-freedom structure and the solutions of these equations for different types of loadings, such as harmonic, periodic, step, and pulse excitations. Numerical time-stepping methods for calculating the dynamics response of systems are presented. The concept of response spectrum is introduced for analyzing the performance of structures and equipment in earthquakes. This course also focuses on the derivation of equations for multi-degree-of-freedom structures such as multi-storied buildings under free and forced vibrations. Finally, the dynamics of continuous systems is presented.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Advanced Steel Structure Engineering

Course Code		CIE8081
Credits	Class hr	Lab hr
3	3	0

This course is about the behavior and design of structural elements in typical steel structures. It covers fundamental principles and comprehensive design procedures for steel structures with practical applications on a various topics. Emphasis will be placed on fundamental design concepts and contemporary design criteria for steel members and systems. Topics will include design concepts and design specifications for tension, compression, beam, beam-column members, and stability for frames as well as their connections. After completing this course, students will be able to explain the behavior of basic structural components of steel structures, use AISC LRFD Code design procedures to design the principal structural elements of steel structures, and participate in the design of steel structures (especially buildings) in a design office.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Compulsory

**Design of Underground Space**

Course Code		CIE8088
Credits	Class hr	Lab hr
3	3	0

Recently, the underground space is widely used for transportation, water supply and storage, electrical and communication cables, hydropower plant, nuclear waste storage and other subsurface facilities. The construction of underground space requires the knowledge of geology, acquirement of design methods, and understanding of excavation methods. Therefore this lecture includes the use of underground space, planning and investigation, and rock mass classification. After studying the geological consideration, initial stress, stress and displacement around underground opening, design method related to support such as shotcrete, rock bolt and steel set, and concrete lining as well as stability analysis related to stress and convergence-confinement methods are covered. After studying design method and stability analysis, excavation, auxiliary measure such as pre-support, grouting, freezing and ground water control, monitoring, ventilation and disaster prevention will be studied. Finally, mechanized construction method such as open TBM and shield TBM is covered.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

**Finite Element Method**

Course Code		CIE8092
Credits	Class hr	Lab hr
3	3	0

The finite element method is one of the most popular numerical analysis in the engineering field. This approach is also a powerful tool to analyze the solid and fluid mechanics. Therefore, the study of this topic is necessary for students and researchers, who are engineering majors. In this finite element course, theoretical approaches for finite element method are first covered in order to understand and develop the procedure of computational algorithm. Then, the variational methods, the weighted residual method, and the Galerkin method are introduced to derive weak formulation of governing equations for solid and fluid which are expressed in strong form. Also, simple linear finite elements and isoparametric finite elements in one, two, and three dimensional coordinates are handled by using ABAQUS, which is a commercial FEM software. Finally, computational techniques to applicate this approach are presented.

**Frequency of offering:** Every Spring**Prerequisite:** Advanced Mathematics, Continuum Mechanics, Computational Mechanics

Classification: Major Elective

## Analysis of Plates and Shells

Course Code		CEE8012
Credits	Class hr	Lab hr
3	3	0

Plates and Shells are very important components in civil and mechanical structures. As the theory of plates and shells is based on analytical approaches, it is required as a basic of engineering mathematics and material mechanics. In this course, theoretical and numerical approaches for linear elastic plates, membrane, and bending theory of axisymmetric shells are introduced. For this, the classical structural mechanics is first educated, and governing equations for plates and shells is derived by simple supported theory like the Navier solution and the Ritz method. In addition, energy formulation to demonstrate the consistent derivation of approximate boundary conditions and edge effects is introduced. Finally, several numerical techniques such as a finite difference method and a finite element method to analyze plates and shells are provided through a simple numerical algorithm.

**Frequency of offering:** Every Spring

**Prerequisite:** Advanced Mathematics, Structural Mechanics, Solid Mechanics

Classification: Major Compulsory

## Advanced Reinforced Concrete Structures

Course Code		CIE8097
Credits	Class hr	Lab hr
3	3	0

Design of a variety of civil engineering structures (Slab, retaining wall, foundation) on the basis of Ultimate Strength design and design techniques will be discussed. Finally, the ability of analysis and design will be developed by giving the opportunity to design reinforced concrete structure. This course covers "design concept of reinforced concrete structures" followed by basic concept of reinforced concrete structure. After completing the course, the student is expected to have understanding for calculation and design of major members in RC structures. The topics of this class include understanding of behavior of RC structures, calculations on safety verification of RC members, skill to design RC structural members and components, skills in engineering that give the basis for construction subjects, using ultimate strength design method of reinforced concrete structures, analysis and design skills will be discussed. Basic concept of flexural design and shear design will be discussed with assigned homework problems.

**Frequency of offering:** Every Other Year

**Prerequisite:** Design of Reinforced Concrete Structures

Classification: Major Elective

**Advanced Reinforced Concrete Structures**

Course Code	CIE8097	
Credits	Class hr	Lab hr
3	3	0

Through numerous examples students will study how to design and analyze. This course covers "design concept of reinforced concrete structures" followed by basic concept of reinforced concrete structure. Ultimate strength design method of reinforced concrete structures of various forms analysis and design skills will be used. Design of a variety of civil engineering structures (slab, retaining wall, foundation) on the basis of ultimate strength design and design techniques will be discussed. Based on the ultimate strength design method and the basic concepts of the theory, students will analyze and design structures with an example in order to increase understandings. Finally, the ability of analysis and design will be developed by giving the opportunity to design reinforced concrete structure.

**Frequency of offering:** Every Other Spring**Prerequisite:** Design of Reinforced Concrete Structures

Classification: Major Elective

**Mechanics of Laminated Composite Structures**

Course Code	CIE8098	
Credits	Class hr	Lab hr
3	3	0

The course is based on the design of composite structural engineering. A guide to understanding fiber-reinforced polymers (FRP) and designing structures with FRP will be discussed. There are four convenient sections, composites for construction covers: (1) An introduction to FRP applications, products and properties, and to the methods of obtaining the characteristic properties of FRP materials for use in structural design, (2) Design of concrete structural members reinforced with FRP reinforcing bars, (3) Design of FRP strengthening systems such as strips, sheets, and fabrics for enhancing the strength and durability of reinforced concrete structural members. The purpose of this course is to gain understanding of fiber reinforced polymer (FRP) composite materials, which have developed into economically and structurally viable construction material for buildings and bridges over the last decades. FRP Composites materials used in structural engineering consist of glass, carbon or aramid fibers encased in a matrix of epoxy, polyester or phenolic thermosetting resins.

**Frequency of offering:** Every Other Fall**Prerequisite:** Design of Reinforced Concrete Structures

Classification: Major Elective

## Computer Application in Construction

Course Code	CIE9082	
Credits	Class hr	Lab hr
3	3	0

The goal of this class is efficient management in construction site using ICT (Information and Communications Technology). It will deal with sensing, automation (especially, machine automation, survey automation) and machine guidance during the class. The class will focus on information technology for heavy equipment operations based on advanced topics in computer-integrated construction. Recent advancement in simulation and sensing technologies enables us to understand and manage construction operations in an unprecedented manner. This part of the course introduces various state-of-the-art simulation and sensing technologies for construction. Also, by introducing several advanced computer-integrated construction methods for real-time planning, monitoring, and control of civil infrastructure projects, this class will covers graphical 3D visualization of construction operations, real-time monitoring of construction processes, mobile computing and information systems for engineering tasks, and robotic systems for construction automation.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Advanced Durability Problems in R/C Structures

Course Code	CIV8005	
Credits	Class hr	Lab hr
3	3	0

This course approaches corrosion and repair techniques that are indispensable subjects to durability of reinforced concrete electrochemically. Durability design of concrete structures introduces the statistical background and explains how models of deterioration processes can be used to predict durability characteristics of concrete structures. The aim is to learn the theoretical background and the design procedure of durability design of concrete structures. Additionally, students will become aware of the corrosion occurring environments. After studying process of initiation and propagation of corrosion conceptually, the repair techniques, which are materials replacement, chemical corrosion inhibitor and coating of steel will be studied intensively. Then, students will learn the deeper electrochemical treatment tech techniques: cathodic protection, chloride extraction and re-alkalization. The main object of this course is to acquire the knowledge and techniques to prevention, diagnosis and repair corrosion of steel in concrete.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Design of Advanced Prestressed Concrete Structure

Course Code		CIV8017
Credits	Class hr	Lab hr
3	3	0

This course includes the basic principles of the construction method of Prestressed Concrete (PSC). Not only the main concepts in PSC which the students have learned in undergraduate course will be covered, but also advanced studies will be discussed. In the latter half of the semester, contents, which are basic materials in concrete structures and complex materials such as cement-polymers that are related to enhance structural performances, will be treated. This lecture will cover basic knowledge of properties, behavior, and measurement of PSC. The topics of this course are methods of PSC, classification (Externally and Internally, Linear and Circular, Pre and Post tension, End anchored and Non end anchored) of PSC, manufacture and construction step of PSC and comparison with RC concrete. Finally, Design of PSC will be conducted by students.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Advanced Coastal Engineering

Course Code		CIV8025
Credits	Class hr	Lab hr
3	3	0

This course introduces maritime engineering, encompassing coastal and ocean engineering. It concentrates on providing an understanding of the many processes at work when the tides, storms and waves interact with the natural and human environments. This course discusses the linearized theory of wave phenomena in applied mechanics. The topics include: small amplitude wave theory based on potential theory including dispersion relationship, phase speed, group velocity, pressure, wave energy, energy flux, etc. The wave transformations in shallow water such as shoaling, refraction, diffraction, reflection, and breaking are also included. The irregular waves are treated as a superposition of multiple monochromatic waves with frequency and directional spectra. The sea level variations due to tides, storm surges, tsunamis and harbor resonance will be introduced for the design of coastal structures.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Fluid Mechanics or Coastal Engineering (Undergraduate)

Classification: Major Elective

## Geotechnical Test and Investigation

Course Code	CIV8036	
Credits	Class hr	Lab hr
3	3	0

This class is a graduate course covering engineering geology and geological survey principles. Students will learn how to use geological engineering information in order to provide expertise on the property behavior of earth materials for underground construction. Because of the nature of soil and rock materials, both laboratory and field testing are very important in geotechnical engineering. Student engineers can begin to develop a feel for soil and rock behavior in the laboratory by performing the standard tests for classification and engineering properties on many different types of soil and rocks. This way, students can begin building up a “mental data bank” of how certain soils and rocks actually look, how they might behave with varying amounts of water in them and under different type of engineering loads, and the range of probable numerical values for the different tests.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topics in Foundation Engineering

Course Code	CIV8039	
Credits	Class hr	Lab hr
3	3	0

This course introduces the general approach to the foundation of design and construction. The course focuses on the evaluation of bearing capacity and of settlement for shallow and deep foundations. To perform satisfactorily, shallow foundations must have two main characteristics: (1) They have to be safe against overall shear failure in the soil that supports them, and (2) They cannot undergo excessive displacement, or settlement. (The term excessive is relative, because the degree of settlement allowed for a structure depending on several considerations) For deep foundations such as driven piles, cast-in-place piles, drilled shafts and micro-piles, important aspects of design and of construction will be introduced and discussed. The design and analysis of pile may be considered somewhat of an art as a result of uncertainties involved in working with some subsoil conditions. This course discusses the present state of the art.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

**Advanced Sewerage Disposal and Treatment**

Course Code		CIV8051
Credits	Class hr	Lab hr
3	3	0

This course is an important part of civil engineering to efficiently use and conserve the water-resources that is indispensable to human beings. The course is designed to offer fundamental knowledge about water and wastewater treatment to students for planning and designing water supply, treatment facilities, sewage collection, and treatment facilities. This course is an advanced level to the principles of wastewater treatment from an engineering perspective, with an emphasis on various skills about municipal wastewater treatment methods and sludge handling. The lecture is designed to deliver professional knowledge to students for keeping pace with globalization and fostering environmental engineers. In addition, the lectures attract voluntary participation and discussion from students to prepare for world class seminars and conferences.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

**Numerical Analysis in Geotechnical Engineering**

Course Code		CIV8052
Credits	Class hr	Lab hr
3	3	0

Numerical modeling in geotechnical engineering is challenging because of many difficulties involved in simulating the complex behavior of soils, including the small nonlinearity, stress path dependency, soil-air-water interaction, in-situ stresses, and spatial variability of the soil properties. Various forms of constitutive models are being used, from the simple elastic law to rigorous plasticity models based on the critical state soil mechanics. Students will explore various soil models that play important roles in the accuracy of the numerical analysis. Also, students will learn how to select the input parameters for the soil models based on laboratory testing. Representative values to be used in the analyses are presented. A specific focus of the course is modeling the nonlinear behavior of soil to simulate various types of geotechnical structures, including staged construction of excavations and foundations. Methods to verify and validate the numerical model will also be presented.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

## Construction Cost Management

Course Code	CIV8059	
Credits	Class hr	Lab hr
3	3	0

This course deals with the cost control method that calculates and determines construction cost reasonably for constructing civil structures, establish budgets, and cope with changes in the budget during the construction. In this course, Cost Management of Construction Projects focuses on the cost manager/quantity surveyor engaged by the project client, and discusses key elements that help drive the success of the project, including measurement (based on the Minimizing Cost Expediting Theory), procurement, cost planning, contract administration and project cost management. With examples, it provides a thorough guide to the role in the workplace and in the field, directly addressing day to day situations faced by the cost manager/quantity surveyor. Also, with the term project, it helps to apply estimation and cost control techniques in practice.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Hydrologic Analysis and Design

Course Code	CIV8073	
Credits	Class hr	Lab hr
3	3	0

Hydrologic processes evolve in space and time in a manner that is partly predictable, deterministic, and/or partly random. Therefore, statistical approaches are introduced in hydrologic analysis and design. This course is intended to introduce students to the advanced hydrologic analysis and design. Students will learn how to analyze the risks inherent in hydrologic design, the selection of design storms including probable maximum precipitation, and the calculation of design flows for various problems including the design of storm sewers, flood control works, and water supply reservoirs. Students are supposed to present their independent studies at the end of semester. Typical examples of independent study are the investigation of effect of climate variation/change on the change of storm runoff, analysis of temporal and spatial characteristics of storm events, forecasting hydrologic/climatic time series for flood mitigation in a watershed.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Hydrology, Probability and Statistics

Classification: Major Elective

**Geotechnical Earthquake Engineering**

Course Code	CIV8077	
Credits	Class hr	Lab hr
3	3	0

The purpose of this course is to provide students with a basic understanding of various concepts of earthquake engineering as related to the principle of geotechnical engineering and equip students with skills to perform numerical simulations. The course will cover both the seismological and geotechnical aspects of geotechnical earthquake engineering. Seismological aspects include topics on seismology, tectonics, and seismic hazard analysis. The geotechnical aspects include topics on site response analysis, liquefaction assessment, and seismic design of geotechnical structures. Geotechnical engineering relies heavily on numerical simulations in estimating the ground vibration and dynamic soil-structure interaction. It is therefore necessary that engineers be familiar with computer programs, as well as seismic code. Programs will be provided for course assignments that require computer programming (using C++ and MATLAB) and performing site response analysis.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

**Urban Stormwater Hydrology**

Course Code	CIV9002	
Credits	Class hr	Lab hr
3	3	0

This class is officially operated in English, including lectures, computer-based exercises, and independent projects on advanced topics of urban stormwater hydrology. The lectures aim to introduce students to the hydrologic processes, the rainfall-runoff relationships in urban areas, hydrologic/hydraulic characteristics of urban flood runoffs, and the effect of urbanization on floods for the sustainable urban development, as well as structural and/or non-structural flood control measures for mitigating flood damage. Students will learn how to analyze the rainfall-runoff relationship in urban areas, and how to combine the hydraulic and hydrologic theories with its real world applications in urban areas. The topics may include the construction of design-storm hyetographs, the calculation of runoff from urban watersheds, the design of stormwater drainage structures, the flood-mitigation measures in urban areas, and the urban stormwater computer models (HEC-HMS, EPA-SWMM).

**Frequency of offering:** Every Other Spring**Prerequisite:** Hydrology, Hydraulics

Classification: Major Compulsory

## Natural Hazards and Disaster Prevention

Course Code	CIV9004	
Credits	Class hr	Lab hr
3	3	0

Disasters are natural and human-caused events that have an adverse impact on community, region, and/or nation. The process of clarifying the nature and impacts of disasters is the foundation of hazard analysis. This course aims to provide a framework for understanding natural hazards and consequences of natural hazards on natural, built, and human environments, and to examine strategies that may be taken at the individual, organizational, community, or regional levels to reduce the adverse consequences of disasters and foster sustainability. The common principles and their applications of disaster mitigation such as earthquakes, floods, tsunamis, droughts, dam failure, etc. are also included to individual case studies in civil and environmental engineering. Students are expected to perform case studies on assessment, mitigation, and preparedness of extreme natural disasters and present their independent studies at the end of semester.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Advanced Physicochemical Treatment Technology

Course Code	CIV9010	
Credits	Class hr	Lab hr
3	3	0

The course objectives are to understand physicochemical and biological processes that transform water pollutants in the natural and engineered environments and to practice these processes. This course brings into focus the aspects of chemistry in terms of equilibrium and kinetics that are valuable for solving environmental problems. This course provides essential physicochemical theories based on reaction engineering and mass transfer phenomena for the analysis of environmental processes occurring in water and wastewater treatment and waste disposal. The course materials include reaction engineering (acid/base, redox, gas/liquid phase et al.), mass transfer theories, chemical processes such as precipitation, adsorption, and ion exchange, and physical processes such as settling, coagulation, filtration, gas transfer, and membrane separation. Softening and neutralization are also treated in this course.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Compulsory

## Advanced Environmental Biotechnology

Course Code		CIV9014	
Credits	Class hr	Lab hr	
3	3	0	

Environmental biotechnology utilizes microorganisms to improve environmental quality. The goal of this course is to understand the advanced principles and applications of the environmental biotechnology. Though quantification of the microbial phenomena is emphasized, qualitative observations will also constitute an important tool to understand the complexity of the microbial world. Students will learn the mechanisms of microbial functioning in pollution control and the applications of the scientific and engineering principles for the design and operation of wastewater treatment plants. Topics include modern microbiology, stoichiometry and bacterial energetics, microbial and biofilm kinetics in growth and pollutants degradation, and analysis of reactors for understanding the basic concepts and quantitative tools. It also includes activated sludge processes, biofilm processes, nutrient removal, and molecular techniques for microbial analysis as applications of the principles.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Water & Wastewater Treatment Processes

Classification: Major Elective

## Advanced Aquatic Chemistry

Course Code		CIV9017	
Credits	Class hr	Lab hr	
3	3	0	

This course is designed to deal with water supply with respect to water resource and policy. Also it covers water purification process such as coagulation, sedimentation, filtration, disinfection, and so on. Advanced treatment processes like membrane and ion exchange would be covered in this course. Students can obtain background theory and basic operation and design procedures for water purification and water service. Students who want this class are required these following efforts for the successful achievement. This course aims to (1) Develop your ability to understand and quantitatively describe the important chemical processes that determine the fate of materials in natural and engineered environments, (2) Develop the ability to apply your understanding of these chemical processes to important environmental problems, and (3) Improve your communication and computer skills.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Technical Communication and Research Ethics

Course Code	CIV9023	
Credits	Class hr	Lab hr
3	3	0

Technical communication is process transferred technology information targeted to a specific audience through media. Information can be useful in case that the audiences targeted decide or behave based on information. Technical communicators are often worked to create deliverables for various media including paper, video and internet. Deliverables are composed of online help, user manuals, technical manuals, the white papers, specifications, processes, procedures manuals, reference cards, data sheets, newspaper articles, patents and training reports for business documents. Research ethics is specifically interested in the analysis of ethical issues that are raised when people are involved as participants in research. The first and broadest objective is to protect human participants. The second objective is to ensure that research is conducted in a way that serves interests of individuals, groups and/or society as a whole. Finally, the third objective is to examine specific research activities and projects for their ethical soundness.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Compulsory

## Numerical Modeling of Porous Media

Course Code	CIV9030	
Credits	Class hr	Lab hr
3	3	0

Numerical simulation has become a critical tool in the design of infrastructures. It is routinely being used both in practice and research. To perform a numerical analysis, understanding of soil behavior, continuum and solid mechanics, numerical techniques for solving boundary value problems such as finite element and/or difference analysis, and soil-structure interaction characteristics are needed. The goal of this course is to equip students with such skills and teach them how to use various types of numerical tools to performing rigorous analyses of geotechnical problems frequency encountered in practice. A large amount of time will be allocated on mechanics and theoretical background of FEM and FDM. Building upon the theories, students will learn guidelines for performing an accurate numerical analysis. A specific focus of the course is to understand constitutive models of porous media and their impact on the predicted response.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

**Statistical Water Resources**

Course Code		<b>CIV9032</b>
Credits	Class hr	Lab hr
3	3	0

This class deals with the basic theories of probability and statistics and their advanced applications for hydrology and water resources, such as hydrologic frequency analysis, statistical inferences, discrete data analysis, the analysis of variance, nonparametric statistical analysis, etc. This course aims to measure quantity and quality of the water in a system, including data collection, data validation, and water accounting techniques, using both ground and remote sensing. Also, upon completion, students should be able to describe different types of water resources data, generated from ground and RS measurements. Lectures will be given for specific topics every week and students are supposed to perform self-directed exercises relating with the topics. The objectives of this class are to learn statistical techniques for water resources and environmental engineering and to learn data explanatory analysis.

**Frequency of offering:** Every Other Fall**Prerequisite:** Probability and Statistics

Classification: Major Elective

**Energy Efficient Smart Construction**

Course Code		<b>CIV9034</b>
Credits	Class hr	Lab hr
3	3	0

The concept of this course is energy saving and smart construction with a domestic and international perspective. The course also covers the concept of machine guidance and fleet management systems using advanced construction technology such as ICT (Information and Communications Technology). The lecture will discuss improvement of the construction quality, productivity and construction cost based on managing construction equipment in large earthwork projects that involves a large number of construction equipment with automation technology. Through this course, students realize that there is a need for advanced information and communications technology based systems to increase the productivity of construction equipment, which may include machine guidance technologies and equipment-energy-usage monitoring systems to minimize energy waste, an important environmental issue, while increasing efficiency.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

## **Fusion Technology and Construction Business Model**

Course Code		CIV9036
Credits	Class hr	Lab hr
3	3	0

Fusion technology can overcome the limitations of individual skills and gain synergies by combining new technologies and existing technologies such as IT, BT, NT. In this way, fusion technology increase productivity and improve the quality of life. It would be high value-added technology. This course undertakes the meaning of fusion technology and examples related fusion technology in construction industry. Also, it will introduce process of construction enterprise and the entrepreneurship that can encourage students to establish the new business associated with their idea and knowledge during their research and study. The purposes of this course are; (1) To introduce fusion technology in construction industry and construction business model and (2) To provide information about business skills, risk management and comparison of the main business model in construction industry.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## **Risk Management for Sustainable Development**

Course Code		CIV9040
Credits	Class hr	Lab hr
3	3	0

The construction industry has had a significant impact on the environment in a variety of ways for the development of economic and social growth. However, in the future, it is necessary to develop a balanced method for both economic & social growth and green growth throughout the development phase in order to meet the needs of the current and future generations. This would be possible by analyzing the risk of uncertainty that may cause during the construction life cycle to take effective responses to achieve economic growth with environmental sustainability. Therefore, this course will focus on the risk management approach, which occurs in the construction industry for environmental, economic, sustainable development, political risk and so on. Based on the analysis of the risk factors in construction, this class will discuss how to manage risks for the sustainable development and how to apply it in construction projects.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

**Membrane-Desalination Processes**

Course Code	<b>CIV9047</b>	
Credits	Class hr	Lab hr
3	3	0

This Subject offers theoretical principles of membrane technology including desalination and their practical application. It provides a comprehensive overview of separation membranes, their manufacture and their applications. Comprehensive and consolidated guide to membrane technology applied to water, wastewater and seawater treatment and reuse/recycling. It also covers microfiltration, ultrafiltration, nano filtration, reverse osmosis, electrodialysis, forward osmosis, membrane distillation, pressure retard osmosis and membrane coupled bioprocesses. It furnishes the necessary derivations and calculations for numerically predicting the separations that can be obtained, based on the known respective membrane permeability. This subject is suitable both as a reference and a textbook for the practicing process engineer, the researcher, and civil, environmental and chemical engineering students.

**Frequency of offering:** Every Spring**Prerequisite:** None

Classification: Major Elective

**Environmental Nanotechnology**

Course Code	<b>CIV9049</b>	
Credits	Class hr	Lab hr
3	3	0

This course will cover the introduction and applications to the types of modern sensing devices for environmental analysis. These are based on the application of advanced nanomaterials and their integration with different signal transduction techniques. In the recent decades, the emergence of nanotechnology and novel nanomaterials has offered developments of convenient, rapid, sensitive and selective devices for environmental analysis. Students will be given examples to the latest nanomaterials/nanosensor for various environmental pollutants, such as heavy metals, pesticides, explosives, toxic gases, bacteria, etc. At the end of the course, students should be able to: (1) Review the characteristics and features of different advanced nanomaterials with respect to environmental analysis, (2) Learn different steps to modify the functional nanomaterials to convert them into molecular probes, and (3) Present (orally) and report (written) some case studies with analytical evaluation.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Compulsory

## **Carbon (Dioxide) Capture, Storage (CCS), and Combustion Engineering**

Course Code	CIV9051	
Credits	Class hr	Lab hr
3	3	0

Anthropologic CO<sub>2</sub> emissions from large-scale sources (e.g., coal fueled power stations) into the atmosphere are increasing exponentially at rate of 2% per year over the last 20 years leading to ever increasing atmospheric CO<sub>2</sub> levels since ca. 1750. The importance and impact of the greenhouse gas, CO<sub>2</sub>, plays in the atmosphere on global climate change and the carbon cycle will be discussed as to why anthropologic CO<sub>2</sub> emissions into the atmosphere need to be reduced by carbon capture and storage (CCS) technologies. The engineering and overall efficiency aspects of CCS will be discussed in terms of energy and financial burdens. Outcomes and competences at the end of the course are to review two papers to identify the key assumptions and critically analyze CCS engineering and perform basic engineering cost/benefit analysis of CCS.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## **Self-Healing Concrete Engineering**

Course Code	CIV9053	
Credits	Class hr	Lab hr
3	3	0

Recently, the development of the new performance concept applied new advanced technology on concrete has increased by researchers in the market of concrete materials. Above all, the development of the sustainability concrete structure applied self-healing performance has been studied by researchers all over the world. The purpose of the technology and performance of the self-healing concrete is to reduce the expenses of repair and maintenance, and extend the usability of the concrete structure. Therefore, this course aims to design the self-healing concrete to improve the durability of the concrete structure and increase the resistibility of the hazardous factors by applying various self-healing technologies, which use suitable materials and properties. Furthermore, products of self-healing will be analyzed through various instrumental analyses.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

**Concrete Structure Maintenance and Repair Engineering**

Course Code	CIV9054	
Credits	Class hr	Lab hr
3	3	0

Most of the infrastructures have been made of concrete because there was nothing to replace the material. However, the durability of concrete reduces as time passes. Therefore, in order to increase the serviceability and maintain the performance of concrete, structures need to go through repair and maintenance. According to environmental factors, the durability of the structure deteriorates and serviceability gradually decreases. Therefore, the decision of repair methods and materials, considering properties of hazardous factors or environmental factors, will be determined by the condition of the site. This course aims to design methods of repair, reinforcement and maintenance by applying suitable materials and methods to construction sites. Furthermore, this class will cover new technologies of repair and maintenance materials and methods.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

**Advanced Solid Mechanics**

Course Code	DME8007	
Credits	Class hr	Lab hr
3	3	0

Solid mechanics is the most fundamental course of engineering. This course covers theories of small & large deformations, stress-strain relationships, constitutive equations, and material & geometrical nonlinear. Before introduction to these theories, students learn essential mathematics such as tensor, linear, and matrix algebra. Then, linear elastic principles are introduced in order to understand simple material behaviors, and nonlinear theories for material and geometry are handled with linearized equation to apply numerical solutions which can solve linear equations. In elastic theory, the Cauchy stress principle, the Force-moment equilibrium, and the Hooke's Law are dealt with. In nonlinear theory, nonlinear elasticity based on a continuum mechanics is covered. Finally, students can learn how to derive constitutive equations and geometry nonlinear equations considering large deformations.

**Frequency of offering:** Every Spring**Prerequisite:** Advanced Mathematics

Classification: Major Compulsory

## Advanced Atmospheric Environment

Course Code	ENS8017	
Credits	Class hr	Lab hr
3	3	0

To understand diverse pollution processes in the atmosphere, e.g., sources and sinks (fate) of volatile organic compounds (VOC) and particulate matter (PM) pollutants and greenhouse gases (e.g., water vapor, methane, carbon dioxide, nitrous oxide), it is important to accurately assess the status of pollution in a quantitative sense. The effect of both indoor and outdoor air pollution on ecology and human health will be modeled and assessed. The impact of air pollutants and greenhouse gas emissions on past and future regional and global climate change including warming will be modeled and critically assessed. At the end of the course, the student should be able to review two papers to identify the key assumptions and critically analyze some chosen models and perform basic inference and draw conclusions from those models.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Probabilistic Structural Engineering

Course Code	ENV8038	
Credits	Class hr	Lab hr
3	3	0

This class deals with the uncertainty in the structural system in order to obtain the response variability in structural responses. To this end, the class deals with the numerical generation of random processes and fields. From the analysis point of view, we consider the statistical and analytical methods such as MCS(Monte Carlo simulation), perturbation and weighted integral methods, and stochastic method. This class aims to understand the uncertainties in the structural system, and to have the ability for the structural analysis based on the probability theory. In particular, as theoretical and practical skills, students perform some projects that have related not only with the numerical generation of random processes and fields but also with the probabilistic analysis by using the finite element method.

**Frequency of offering:** Every Spring

**Prerequisite:** Advanced Mathematics, Finite Element Method

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Computer and  
Software Engineering**



Classification: Major Elective

## Computer Networks

Course Code	CCE0008	
Credits	Class hr	Lab hr
3	3	0

This course provides comprehensive coverage of computer networks. It is intended to provide students an understanding in the Internet and its corresponding TCP/IP protocol architecture as examples. It covers the advanced concepts such as Hyper-Text Transfer Protocol (HTTP), TCP congestion control, IP routing and firewall. Details of the protocol layers of the Internet are explained, as well as hardware and software associated with the Internet, including the application, transport, and network layers except for data link, medium access, and physical layer. Students will perform a couple of projects of suggest topics to understand some practical aspects of the principle concepts. The purpose of this lecture is students to improve their knowledge about computer network, especially architecture and protocol as well as basic concept. Based on these concepts, students can have the ability to implement and utilize the network algorithm and program. Students will also learn the concept and capability through experimental projects.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topics on Operating Systems

Course Code	CCE0013	
Credits	Class hr	Lab hr
3	3	0

This course introduces advanced concepts of operating systems. Specifically, this course will cover modern concepts of operating system structures for multicore hardware, multithreading, memory management and storage management issues. In this course, students will also study a number of recent articles in the operating systems area, which include modern concepts of operating system structures, multithreading, memory management, storage management, networking and distributed systems issues. Students will also learn how to find, formulate, solve research problems on operating systems, and how to present them in the form of a research article. This course aims to cover fundamental OS concepts, multicore hardware and parallelism, OS structures and multicore issues, and multicore programming and performance issues.

**Frequency of offering:** Every Spring

**Prerequisite:** Operating Systems, Computer Architecture, C Programming

Classification: Major Elective

**Network Security**

Course Code		CCE0031
Credits	Class hr	Lab hr
3	3	0

This class gives an overview on computer security and network security. More specifically, you will learn about basic cryptography, security systems, security issues in software and network. Most system faults are caused from software bugs, and attackers exploit software bugs to attack various systems. This class will cover the following issues to understand attacks and to implement countermeasures against network attacks: Basic Cryptography: Symmetric (DES, 3DES, AES, etc.) and Asymmetric (RSA) Encryptions, Block cipher and stream cipher, mode of operations, Overviews of Computer Security: Various attack methods (buffer overflow attacks, denial-of-service attacks and etc.) and their countermeasures, System Protection: Security products including intrusion detection systems, intrusion prevention systems, firewalls and etc., Security Issues in Various Network Environments, and Malware Analysis including static analysis as well as dynamic analysis

**Frequency of offering:** Every Other Fall**Prerequisite:** Operating Systems, Computer Networks

Classification: Major Elective

**String Algorithms**

Course Code		CCE6002
Credits	Class hr	Lab hr
3	3	0

In this class, students study the general, rigorous text on deterministic algorithms that operate on strings, trees, and sequences. It covers the full spectrum of string algorithms from classical computer science to modern molecular biology and, when appropriate, connects those two fields. The string algorithms taught in this class are categorized into three major topics which are exact string matching algorithms, algorithms on and using suffix trees and suffix arrays, and approximate string matching algorithms. Exact string matching algorithms include naïve matching, KMP algorithm, BM algorithm, and Aho-Corasick algorithm. Algorithms on and using suffix trees and suffix arrays include suffix trees and arrays construction and fast string matching using suffix trees and arrays. Approximate string matching algorithms include edit distance computation, string similarity computation, global alignment and local alignment with/without gaps.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## Project-Based Learning

Course Code	CSW6013	
Credits	Class hr	Lab hr
3	3	0

Computer and software technology is rapidly changing and evolving. This course will provide students with the opportunity to explore current and emerging technology issues and to investigate and examine potentiality of new technology. This graduate course is designed to let students learn by engaging group and/or individual project activities. In this exciting course, Students will be given various shapes and sizes of projects which is about carefully selected up-to-date technology topic. Students will also gain practical knowledge and skills about related project management. Extensive and advanced readings, research will be required. In this class, students will learn how to identify requirements of a project, how to design the project, how to implement the project, and how to test and validate the project.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Information Network

Course Code	CSW6016	
Credits	Class hr	Lab hr
3	3	0

An information network is a graph structure modelling members and their relationships as nodes and edges. Information networks research has progressed from different disciplines such as psychology, sociology, physics, statistics, and computer science since the notable six-degree separation experiment. In recent years, information networks research has advanced significantly, thanks to the prevalence of the online societies such as Twitter, Facebook, Tumbler, and Google+. In particular, researchers working in a data mining area are increasingly interested in addressing a wide range of challenges residing in huge online information networks, including identifying common static topological properties and dynamic properties during the formation and evolution of these networks. In this course, we study information network analysis techniques in the data mining perspective. The main goals of this course are as follows: (1) to learn the state-of-the-art technology for analyzing information networks; (2) to understand the applications for which the technology of analyzing information networks is useful; (3) to understand the recent trend of the research on information network analysis; (4) to devise a novel idea, to implement it, and to perform experiments for showing its superiority; (5) to improve technical communication skill in English.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Engineering Writing for Publication in English & Research Ethics

Course Code		ECE8085
Credits	Class hr	Lab hr
3	3	0

Publishing articles in English in international journals is an essential skill for career success in the sciences. Writing in English is also an essential skill for working in a global market. However, there are few writing classes in Korea that teach scientific research writing. Despite this, many students are expected to publish their research in English in graduate school. The purpose of this class is to provide students with the English technical writing skills they need to help write conference papers, journal articles, theses or dissertations in English. Essential writing principles, common grammar problems, and best practices for writing each part of the research article will be covered. Basic business email writing skills and computer-assisted writing for self-editing will also be taught. Students will choose content in their own field when writing assignments. There will be no general writing assignments that are not related to the students' research fields.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Software Security

Course Code		EWE8082
Credits	Class hr	Lab hr
3	3	0

This class gives overviews on computer security and software security. More specifically, students will learn basic cryptography, security systems, and security issues in software development. Grades will be determined based on class participation, examinations and term papers. Since most system faults are caused mostly from software bugs, it is quite important to build softwares with almost no bugs. Software security deals with this kind of issues. This class will covers the following topics: 1) Basic Cryptography, 2) System Protection, 3) Overviews of Computer Security, 4) Security Issues in Software Development Cycles, 5) Basic concepts on computer security, 6) Theories and algorithms on computer security, and 7) The importance of security in IT environments.

**Frequency of offering:** Every Fall

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Electrical Engineering**



Classification: Major Elective

## Advanced High Voltage Techniques

Course Code	ELE6035	
Credits	Class hr	Lab hr
3	3	0

The goal of this class is to introduce high voltage techniques in advanced level. Electromagnetics and circuit theory are prerequisite for students. In this course students get to study the following themes; (1) the application of numerical methods in electrical stress calculations, (2) the electrical breakdown of gases, solid and liquid dielectrics, (3) the apparatus used in the generation of AC, DC and impulse voltages, (4) the topic of high voltage measurements, (5) the fundamental introduction to dielectric properties of materials, diagnostic test methods, and non-destructive tests applicable also to on-site monitoring of power equipment, (6) the topics of lightning phenomena, switching overvoltages, insulation coordination and statistically based laboratory impulse test methods, and (7) the design, performance, application and testing of outdoor insulators.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Advanced Power System Analysis

Course Code	ELE6039	
Credits	Class hr	Lab hr
3	3	0

In power system, there is the decomposition of the four components such as generation, transmission, distribution and substation system. As a result of advancements in the electric power industry, the power system has been becoming more complicated. Therefore, the operation and control of power system have been becoming more difficult. In this lecture, we will study about the power system analysis related to a series of processes on how the generated electrical energy is transferred to consumers through transmission, substation, and distribution systems. For this reason, at first, basic theories and methods on the components of power system and methods for the modeling will be discussed. And then, the following contents related to the overall power system engineering field will be studied: power flow analysis, contingency analysis, power system control, basic theory of electricity power market and economic dispatch, state estimation of power system and so forth.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Advanced Digital Signal Processing

Course Code	ELE6043	
Credits	Class hr	Lab hr
3	3	0

In this course, students will study vector space methods for signal processing. Students will learn basic fundamentals on subspace and least square methods. Many signal processing problems can be described by linear operators and vector space methods, which are studied in this course. It can be useful for solving the inverse problems. In this course, we particularly emphasize the disciplines of logical thinking, rigorous proof and derivation of mathematical theorems. Next, we will cover various advanced vector space methods such as recursive least square (RLS), MUSIC, and ESPRIT algorithms and discuss application of these algorithms to direction of arrival (DOA) estimation, spectral estimation, and adaptive beamforming. Also, this course takes a look at useful matrix factorization methods such as singular value decomposition (SVD) and nonnegative matrix factorization (NMF).

**Frequency of offering:** Every Other Fall

**Prerequisite:** Linear Algebra, Signal and Systems

Classification: Major Elective

## Detection and Estimation Theory

Course Code	ELE6048	
Credits	Class hr	Lab hr
3	3	0

This course teaches the fundamental theory of detection and estimation. Estimation and detection theory is an important element of information and signal processing, which is found in many areas such as communications, automatic control, radar, and machine learning. In this course, we mainly focus on statistical approach to detection and estimation methods. The first half of this course is on detection theory which covers Bayesian hypothesis testing, Neyman-Pearson criteria, min-max testing, composite hypothesis testing, sequential detection etc. The second half will cover estimation theory including minimum variance unbiased estimation (MVUE), maximum likelihood estimation, Cramer-Rao lower bound, Bayesian estimation theory, expectation and maximization (EM) algorithm and Kalman smoother. We also discuss sequential Monte-Carlo sampling method as well as particle filter. If time is allowed, we will study practical applications of the detection and estimation theory to various signal processing examples.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Probability and Statistics, Random Process

Classification: Major Elective

## Photonic Crystals

Course Code	<b>ELE6051</b>	
Credits	Class hr	Lab hr
3	3	0

Many of the true breakthroughs in our technology have resulted from a deeper understanding of the properties of materials. In this century, our control over materials has spread to include their electrical properties. Advances in semiconductor physics have allowed us to tailor the conducting properties of certain materials, thereby initiating the transistor revolution in electronics. It is hard to overstate the impact that the advances in these fields have had on our society. In the last few decades, a new frontier has opened up. The goal in this case is to control the optical properties of materials. An enormous range of technological developments would become possible if we could engineer materials that respond to light waves over a desired range of frequencies by perfectly reflecting them, or allowing them to propagate only in certain directions, or confining them within a specified volume. Already, fiber-optic cables, which simply guide light, have revolutionized the telecommunications industry. Laser engineering, high-speed computing, and spectroscopy. The optical analogue to solid state crystals is the photonic crystal, in which the atoms or molecules are replaced by macroscopic media with differing dielectric constants, and the periodic potential is replaced by a periodic dielectric function. If the dielectric constants of the materials in the crystal are sufficiently different, and if the absorption of light by the materials is minimal, then the refractions and reflections of light from all of the various interfaces can produce many of the same phenomena for photons that the atomic potential produces for electrons. One solution to the problem of optical control and manipulation is thus a photonic crystal. In particular, we can design and construct photonic crystals with photonic band gaps, preventing light from propagating in certain directions with specified frequencies. We will also see that a photonic crystal can allow propagation in anomalous and useful ways.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Numerical Methods and Modelling

Course Code	ELE6053	
Credits	Class hr	Lab hr
3	3	0

Numeric analysis or briefly numeric continues to be one of the fastest growing areas of engineering mathematics. This is a natural trend with the ever greater availability of computing power and global Internet use. Indeed, good software implementation of numerical methods is readily available. This course provides the students in engineering curriculum stepwise how to use these computer algebra systems with complete engineering examples drawn from the text. In a career as an engineer, applied mathematician, or scientist, students are likely to use commercially available software or proprietary software, owned by the company that uses numeric methods to solve engineering problems, such as modeling chemical or biological processes, planning ecologically sound heating systems, or computing trajectories of spacecraft or satellites. A solid knowledge in numeric analysis will be introduced in this course.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Machine Learning Theory

Course Code	ELE6055	
Credits	Class hr	Lab hr
3	3	0

In this course, students will focus on basic principles of machine learning. First, we will review basic probability and random variable theories. Then, linear models for regression and classification are introduced and various statistical inference methods are presented in depth. Various classification tools such as support vector machine (SVM), K-means clustering, and multi-layer perceptron will be presented and kernel-based nonparametric approach will also be discussed. Students will learn basic data representation methods such as PCA, LDA, graphical model, and Gaussian mixture model and apply them to the real data as an example. Finally, this course will introduce the emerging deep neural network and its several applications including object detection, speech recognition, natural language processing, and time series analysis. The concept of the reinforcement learning will be briefly presented if time allows.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Probability and Statistics, Linear Algebra

Classification: Major Elective

## Design and Control of Traction Motor

Course Code	ELE7017	
Credits	Class hr	Lab hr
3	3	0

Recently, as environmental problems like global warming and air pollution caused by fossil fuels have become important issues, the world is focusing on the research and development of the electric car to reduce the use of fossil fuels. Especially, IPM motor is known as a good candidate for the hybrid electric vehicle traction drive application due to its unique merits like little volume, light weight, high efficiency and power factor and high reliability. Also, IPM motors are very high degree of freedom in design and in control aspect, compared to other motors because the magnetic torque and reluctance torque can be used simultaneously. Therefore, in this course we will study about the advanced theory of design and control of IPM motor.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Linear System I

Course Code	ELE7030	
Credits	Class hr	Lab hr
3	3	0

The purpose of this course is to provide the students with the basic tools of modern linear systems theory: stability, controllability, observability, realization theory, state feedback, state estimation, separation theorem, etc. In addition, the specific courses covered in this course also include: Multivariable poles and zeros, Smith-McMillan form, poles, transmission and invariant zeros, McMillan degree & minimal realizations, LQR/LQG control, ARE, Kalman's inequality, frequency-domain properties of LQR, loop-shaping using LQR, the cheap control, problem, Minimum Energy (ME) state estimators, Stochastic LQG/LTR. For time-invariant systems both state-space and polynomial methods are studied. The students will also be introduced to the computational tools for linear systems theory available in MATLAB. The intended audience for this course includes, but is not restricted to, students in circuits, communications, control, signal processing, physics, and mechanical and chemical engineering.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Advanced Energy Engineering

Course Code	ELE7040	
Credits	Class hr	Lab hr
3	3	0

Energy is one of the most critical subjects for mankind in the 21<sup>st</sup> century. As the energy demand/consumption increase, energy engineering becomes more and more important regarding how to produce energy, how to convert the produced energy to another form, and how to enhance the conversion efficiency. As non-fossil and non-renewable energy sources, the basic principle of nuclear energies such as fission, fusion and hybrid energies are main topics of the course. Fusion energy: definition of plasma, single particle model, fluid model, diffusion processes, magneto-hydro-dynamic model, magnetic fusion device (tokamak), plasma-surface interaction. Fission energy: status of fission nuclear energy, multiplication factor of neutron, and power distribution of fission nuclear reactor. Hybrid energy: fusion-fission hybrid reactor. Comparison with renewable energy sources will be given.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Special Topics of Control Engineering

Course Code	ELE9083	
Credits	Class hr	Lab hr
3	3	0

The goal of this course is to teach the fundamentals of the vehicle control systems. A vehicle has 4 groups of electrical and electronic systems, powertrain control (including engine, transmission, HEV/EV control systems), safety control (including chassis and airbag control systems), convenient control (including body, cluster, and AC control systems), and infotainments (multimedia and ITS). A vehicle control system consists of electronic control units (ECU), sensors, actuators, and wire harness. This course deals with, especially, the HW and SW structure of the control systems for powertrain, safety, and convenient systems. Therefore, this course covers principles and characteristics of the ECU hardware and software, development procedure of an ECU, principle of sensors, principle and control of actuators. This course also covers intelligent vehicle issues such as ADAS sensors (Radar, Vision, and GPS) and communications (CAN and WAVE).

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topic in Plasma Processing

Course Code	ELE9089	
Credits	Class hr	Lab hr
3	3	0

The course is presented as a seminar class. Therefore, emphasis will be given on reading, assimilation and application of present literature on Plasma Sources and Plasma Processing. Students will be expected to rapporteur their finding to the class at regular intervals through the course, with the ultimate goal of bringing the entire class to better understanding of the wide-ranging plasma physics and processing topics involved. The course topics include introduction to plasma, basic plasma physics/chemistry, Etch/Deposition reactor configurations, Etching/Deposition parameters, modeling and simulation, process monitoring and endpoint detection, process control, Etching specific materials, deposition of specific materials, and damage issues.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Particle-in-Cell Simulations of EM/Plasma Systems

Course Code	ELE9101	
Credits	Class hr	Lab hr
3	3	0

Vacuum electronic devices and electromagnetic plasma systems in the modern era are becoming more and more complicated. In order to understand the principles and operation characteristics of these EM/Plasma systems, computer modeling is required. In this course, the origins, history, recent development of particle-in-cell (PIC) methods will be introduced. Students will review the fundamentals of PIC simulation methods as well as other numerical techniques for studying EM/Plasma models. The Plasma Theory and Simulation Group (PTSG) codes developed by PTSG, formerly at UC Berkeley and now at Michigan State University, will be introduced and used in this course. In addition to classical lectures on the basic theories, numerical algorithms, and formulation of different models, from a computer environment setup, installation of the packages, compilation of source codes and input files to building realistic models such as capacitive coupled plasma discharge and inductively coupled plasma discharge will be practiced during hands-on sessions.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Statistical Signal Processing

Course Code	ELE9105	
Credits	Class hr	Lab hr
3	3	0

In this course, students will study a variety of modern statistical signal processing approaches. First, students will briefly review the basic probability and random process theories as well as the basic statistical estimation framework such as Bayesian inference algorithm and maximum likelihood estimation. Then linear estimation theory covering linear MMSE, gradient descent method, Neuton's method, and LMS algorithm will be studied. Students learn to describe signals and systems using the stochastic models such as hidden Markov model (HMM), Gaussian mixture model, auto-regressive moving average (ARMA) model, Bayesian network, random Markov field, and Gaussian-Markov process. Finally, various inference tools are also introduced, including the forward-backward algorithm, Viterbi algorithm, Levinson-Durbin algorithm, Baum-Welch algorithm, expectation-maximization (EM) algorithm, message-passing algorithm, and etc.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Probability and Statistics, Random Process

Classification: Major Elective

## Plasma Source Engineering

Course Code	GAF8078	
Credits	Class hr	Lab hr
3	3	0

This course covers recent plasma source issues by reading recent papers on the plasma sources and processing. An overview of commercially important plasma sources, including the fundamental principles of their operation will be presented. Understanding of the concepts required for choosing plasma sources for applications and evaluating source performance will be developed. A sound basis for the specification of critical performance parameters will be given to the student. Modern techniques of plasma reactor modelling and hands-on experience in using selected software packages will be introduced and given to the student. We cover four major topics: fundamentals of plasma, Equipment Technology, Plasma diagnostics, and Plasma Generation. Each of these topics can be studied independently. Engineers using plasma processing need to understand a wide range of topics related to both the technology of reactors and the properties of plasmas.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

H A N Y A N G U N I V E R S I T Y

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Department of  
**Electronic Engineering**



Classification: Major Elective

## Probability and Random Process

Course Code	CCE0004	
Credits	Class hr	Lab hr
3	3	0

The use of probability models and statistical methods for analyzing data has become a common practice in virtually all scientific and engineering disciplines, especially in modern electrical, electronic, and communication systems. The goal of this course is to provide a rigorous introduction to the probability theory, and to cover basic concepts and applications in random processes. The course begins with fundamentals in set theory and probability space, conditional probability, probability density functions for random variables (RVs), Gaussian random variables, mean and variance, characteristic functions, joint density functions, and transformation of RVs. The course then moves to the elementary properties of random processes, including statistical averages of random processes, auto- and cross-correlation functions, stationary random processes, ergodic processes, and power spectral density. Some special models of random processes are also covered, including the Bernoulli processes, random walk, Gaussian processes, Poisson processes, and Markov processes.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Communication IC Design

Course Code	CCE0010	
Credits	Class hr	Lab hr
3	3	0

The radio frequency (RF) and wireless market has suddenly expanded to unimaginable dimensions. Semiconductor and system companies have seen the statistics and are striving to increase their own market share by introducing various RF products. This course deals with the study of fundamental theories and practices to design RFICs and RF systems. It begins with the necessary background knowledge from the microwave and communication theory and leads students to the design of RF transceivers and circuits. Theories include basic concepts in RF design, modulation and detection, multiple access techniques and wireless standards, transceiver architecture, low noise amplifier (LNA), oscillators, frequency synthesizers, and power amplifier (PA). All theories will be examined and trained with a modern RF simulator, Agilent's ADS or other preferred simulators. Students will achieve practical experience of simulation for RF ICs and systems through term-projects

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

**Advanced Wireless Network**

Course Code		<b>CCE0081</b>
Credits	Class hr	Lab hr
3	3	0

Recently there has been a great deal of interest in Vehicular IoT technology because of its most realistic deployment of IoT services and business. The connectivity of a vehicle to the outside internet can be provided by various wireless communications, among which mobile communication, WiFi, and vehicular wireless communications are the most important. In this course, vehicular wireless communication systems including WiFi are introduced and discussed in terms of their protocols and applications. There are two internationally-standardized vehicular communications of WAVE (Wireless Access in Vehicular Environment) in IEEE and CALM (Communication Access for Land Mobiles) in ISO. V2X connectivity using them has been recognized essential for Autonomous Driving and Vehicular Big-Data Collection. We discuss the characteristics of Access layers including microwave carrier, modulation, data rate, coding, multiple access, QoS, multi-channel operation etc. The Network layer supports a Fast Network Protocol as well as IPv6. The former may be the most significant characteristic distinguished from other wireless communications, ensuring safe and convenient driving. The course also introduces some useful safe-driving applications using them.

**Frequency of offering:** Every Spring**Prerequisite:** Communication Theory, Digital Communication

Classification: Major Elective

**Nano Technology. Physics Seminar**

Course Code		<b>CCE0083</b>
Credits	Class hr	Lab hr
3	3	0

Investigations of nano technology have been particularly interesting because of their fundamental physical properties and their potential applications in electronic and optoelectronic devices. The quantum mechanics related to nano technology and physical properties of the nanomaterials are discussed. The steady-state Schrödinger equations in one and three dimensions are discussed. The operator methods in quantum mechanics are discussed. The solving methods of the eigenvalues and the eigenfunctions for various quantum structures are discussed. The fabrication and characterization of metal-oxide-semiconductor diodes, semiconductor heterostructures, and semiconductor quantum wells are discussed. The fabrication and physical properties of field-effect transistors are discussed. The fabrication and physical properties of memory devices are discussed. The nano technology and physical properties of nanomaterials for applications in the nanodevices are discussed.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## **Convergence Information Technologies (IT) Colloquium**

Course Code	CEE0087	
Credits	Class hr	Lab hr
3	3	0

Convergence of information technologies is the tendency that as technology changes, different technological systems sometimes evolve toward performing similar tasks. Investigation of quantum and nano devices has been particularly interesting because of their potential applications in next-generation electronic and optoelectronic devices and power device in the convergence information technologies. The basic concepts of modern physics and quantum mechanics are described. The fabrication and physical properties of the quantum electronic and optoelectronic devices fabricated utilizing quantum structures in the convergence information technologies are discussed. The fabrication and physical properties of the nano electronic devices and nano optoelectronic devices fabricated by using nano scale structures in the convergence information technologies are discussed. These contents can help improve understanding potential applications of electronic and optoelectronic devices utilizing quantum and nano structures in the convergence information technologies.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## **Modem Design for Communications**

Course Code	ECE6007	
Credits	Class hr	Lab hr
3	3	0

Modem is one of the most important elements of communication systems. Many researches on communications are performed assuming perfect phase, time and frequency synchronizations. However, in real environments, it is necessary to acquire the related information. In this course, we will study basic theories and technologies to implement communication modems. In this class, we will study the basic concepts of PLL (Phase Locked Loop) and its applications. Especially, we will study phase-synchronization, time-synchronization, frequency-synchronization, automatic gain control and so on. Based on these studies, a simple modem can be designed for communication. Also, some advanced concepts will be introduced to design CDMA (Code Division Multiple Access) and OFDM (Orthogonal Frequency Division Mutiplex) modems. In addition, some RF control techniques will be introduced.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Channel Coding

Course Code		ECE8032
Credits	Class hr	Lab hr
3	3	0

Today, digital data transmission and storage are frequently occurred in every-day life. Therefore, it is very important to use communication systems and data storage systems to reliably transmit or store digital data. Nowadays, as the demand for more reliable and efficient data transmission and storage is ever increasing, strong error-correction schemes are required, which can efficiently combat the errors occurred from the noisy channel such as communication channel or storage media. This course deals with various schemes for detecting and correcting errors occurred when the information data is transferred and stored. In this course, first, the error sources are defined and analyzed. Then based on the fundamental knowledge about algebra and probability, block codes and convolutional codes are introduced and their various encoding and decoding schemes are studied. Because knowledge about fundamental mathematics such as linear algebra and probability theory is indispensable, it is strongly recommended that a student should take linear algebra and probability theory as prerequisites for this course.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Linear Algebra, Probability Theory

Classification: Major Elective

## Semiconductor Circuit Design for Communication

Course Code		ECE8078
Credits	Class hr	Lab hr
3	3	0

A basic telecommunication system consists of three primary units that are always present in some form: (1) A transmitter that takes information and converts it to a signal, (2) A transmission medium, also called the "physical channel" that carries the signal. (i.e. "free space channel"), and (3) A receiver that takes the signal from the channel and converts it back into usable information. To carry on the above function, two basic chips are needed, called baseband or Media access control (BB/MAC), and Physical layer functions (PHY). This course is an introduction to BB/MAC design including topics of propagation delay, noise margins, power dissipation, and regenerative logic circuits. We will look at various design styles and architectures as well as the issues that designers must face.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Computer Communications

Course Code	ENE8051	
Credits	Class hr	Lab hr
3	3	0

In recent years, computer communication technologies have extended their applications between smart phones including Internet of Things (IoT) such as sensors and home devices. Moreover, new concepts such as software defined network (SDN) and network function virtualization (NFV) are created and being widely adopted by the communications industry. As very sensitive and valuable information is exchanged through communication networks, security vulnerability and threats become more significant. This course will serve as an introductory level course on computer communications in the graduate level but with assumption that students have taken a similar course in their undergraduate studies. This course will include Wi-Fi technologies, Internet operation and quality of services. Finally, IoT, SDN, and NFV, multiprotocol label switching (MPLS) for transport networks will also be covered.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Analog Integrated Circuit Design

Course Code	ENE8079	
Credits	Class hr	Lab hr
3	3	0

The goal of this course is to learn how to analyze and design CMOS analog integrated circuits, from process technology to circuit-level design. The course will mainly focus on analog integrated circuit design with key design factors, design methodologies, performance analysis, and practical issues in analog circuit design. Moreover, in-depth knowledge and design techniques of the analog integrated circuits will be provided with several design examples such as operational amplifier, ADC, and DAC. The topics of this course are basic MOS device physics, single-stage amplifiers, differential pairs, operational amplifier, feedback, various biasing techniques including current mirrors, frequency response characteristics of broadband amplifiers, and precision voltage references. This course requires an undergraduate level knowledge of electronic circuits and solid state electronic devices.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

**Computer Architecture**

Course Code		ENE9019
Credits	Class hr	Lab hr
3	3	0

Recently computer systems are required to have high computing capability due to the emergence of new applications such as artificial intelligence, virtual reality, big data, etc. Performance enhancement in computer systems is often resulted from hardware technology improvement, software algorithm optimization, and other parallelization techniques. In this class, we study the principles and techniques for designing high-performance computer systems from a quantitative viewpoint. Topics covered will include performance metrics, instruction set principles, pipelining, hazards and exceptions handling in pipeline, cache and virtual memory and their performance, I/O systems, interconnection networks, and multiprocessors. In addition, the architecture of GPUs and parallel processors will be analyzed and discussed as a way of improving legacy computer system performance.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

**Information Display Engineering 3**

Course Code		ENE9062
Credits	Class hr	Lab hr
3	3	0

The major topics of this course include driving methods and circuits of various flat panel displays such as TFT-LCD and Organic Light Emitting Diodes (OLEDs). Circuit design with thin film transistors (a-Si:H TFT, LTPS-TFT and Oxide TFT) integrated on substrates are also covered. Students will learn how the driving method affects the performances of display devices, especially the image qualities and power consumption. Driving circuits are basically mixed-mode circuits composed of digital logic blocks and analog circuits. Thus, students are required to have sufficient knowledge of digital and analog circuit design. The fundamentals of the driving circuit design will be presented. Then the course will move one to advanced topics including low-power, high-speed, and low-area circuit design. OLED driving methods will be studied together with pixel circuit design. LTPS- or Oxide-TFTs are mostly used for OLED pixels, but their characteristics are not uniform or stable, thus requiring sophisticated compensation circuits in the pixel. The circuit design with TFTs is quite different from the traditional semiconductor circuit design because of their characteristics. Therefore, students will learn approaches of circuit design different from the traditional one based on the understanding of TFT characteristics.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## Microwave System

Course Code	EWE8014	
Credits	Class hr	Lab hr
3	3	0

Modern microwave engineering involves mainly distributed circuit analysis and design, in contrast to the waveguide and the field theory orientation of earlier generations. The majority of microwave engineers today design planar components and integrated circuits without direct recourse to electromagnetic analysis. Thus, this course covers theory and design techniques for microwave devices: transmission-line theory, microwave network analysis including a scattering-parameter, methods of impedance matching and tuning, power dividers and directional couplers, microwave filters, mixers, and amplifiers. All theories will be practiced with a modern microwave simulator, Agilent's ADS. Students will have experiences with a microwave circuit simulation, optimization, and layout process. Fabrication and the measurement of designed circuits are helped by well-trained teaching assistants. This course is organized as a three-hour class for theory and a two-hour class for experiment in a week.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Antenna Design

Course Code	EWE8015	
Credits	Class hr	Lab hr
3	3	0

The topic of this course is to understand the fundamental theory and principles of antenna design for mobile devices. The course starts with the introduction to the fundamental concept of mobile antenna design, basic radiation mechanism of mobile antennas, and covers in-depth study of reactive near fields, radiative far fields, radiation resistance, radiation efficiency, radiation bandwidth, impedance of antennas, and characteristic mode theory of radiating structures. Mobile antennas are modeled using two fundamental sources of electromagnetic wave, electric current and magnetic current. The two fundamental sources are electric dipole antenna and magnetic dipole antenna, of which radiation principle is discussed in mobile devices. It is assumed that the students already have some acquaintance with electromagnetic field theory and with electric circuit theory.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Electrical Circuit Theory, Electromagnetic Field Theory

Classification: Major Elective

**Scattering of Electromagnetic Waves**

Course Code	EWE8019	
Credits	Class hr	Lab hr
3	3	0

The topic of this course is to understand scattering of electromagnetic waves under various conditions. The electromagnetic wave is scattered when incident upon the conductor, dielectric material or magnetic material. This course starts with the fundamental concepts which form the basis of electromagnetic wave phenomena. It continues with introduction of waves, some theorems and concepts, plane wave functions, cylindrical wave functions and spherical wave functions. The interaction of electromagnetic wave and electromagnetic object (conductor, dielectric or magnetic material) is modeled using reaction concept (self-reaction and mutual reaction), and impedance or admittance matrix. The course deals with scattering theory of conducting or dielectric structures, radar cross section (RCS) concept and echo area. It is assumed that the students already have some acquaintance with electromagnetic field theory and with electric circuit theory.

**Frequency of offering:** Every Other Fall**Prerequisite:** Electromagnetic Field Theory, Electric Circuit Theory

Classification: Major Elective

**Radio Wave Communication Engineering**

Course Code	EWE8020	
Credits	Class hr	Lab hr
3	3	0

The main objective of this course is to introduce the basic concepts of radio wave communication. Radio wave communication engineering plays a key role in communication in very low frequency (VLF), low frequency (LF), medium frequency (MF), high frequency (HF), very high frequency (VHF), ultra high frequency (UHF), super high frequency (SHF), extremely high frequency (EHF) bands. Starting with a brief introduction to radio frequency spectrum, we will move to Friis transmission equation, radio communication channel, and radio wave propagation in urban, suburban, rural, space environments including troposphere and stratosphere. Also covered are radio wave reflection mechanisms and antennas. Finally, we will study multipath fading phenomena and statistical descriptions of radio wave signals. This course requires a sound knowledge of undergraduate electromagnetic theory.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## Opto-Electronic Devices

Course Code	EWE8024	
Credits	Class hr	Lab hr
3	3	0

This course covers optoelectronic devices that emit, control and detect light. The optoelectronics devices include light emitting-diodes, lasers, photodetectors, and solar cells. In order to understand the physical properties of semiconductors and metals, basic quantum mechanics is introduced; the time-independent Schrödinger equations are solved for the wave functions and eigenvalues, and the results are interpreted physically. This course deals with the equilibrium and biased states of the various junctions and the flow of electrons and holes across a junction under steady-state and transient conditions. This course also covers fabrication and characterization of optoelectronic devices. Applications of optoelectronic devices such broadband telecommunications and data transmission over optical fibers are provided. Furthermore, this course introduces next-generation optoelectronic devices and their promising application areas.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Modern Physics

Classification: Major Elective

## Advanced Electromagnetics Theory

Course Code	EWE8039	
Credits	Class hr	Lab hr
3	3	0

The main objective of this course is to introduce basic relationships for electromagnetic fields, wave equation, plane wave solutions, and electromagnetic fields of sources. Advanced electromagnetics theory plays a key role in microwave and optical technologies including microwave circuits, antennas, waveguides, and cavities. Starting with a brief introduction to Maxwell's equations, we will move to boundary conditions, electrical properties of matter, and wave equation and its solutions. We will follow wave propagation and polarization in unbounded regions and then discuss wave reflection and transmission of material interface. Also covered are electromagnetic potentials which are basic mathematical tools to analyze and design antennas. Finally, we will study electromagnetic theorems and waveguides and cavities. This course requires a sound knowledge of undergraduate electromagnetic theory, including Maxwell's equations and transmission line theory.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

**Special Topics in Semiconductor and VLSI**

Course Code	EWE8047	
Credits	Class hr	Lab hr
3	3	0

Semiconductor and VLSI technologies are very important in today. In a single chip now up to billions of transistors are fabricated using state of the art device manufacturing technologies. Furthermore, in a typical single VLSI chip, digital and analog circuits are combined to enable the required performance. Because the technology changes very rapidly, it is very important to keep pace with it. This course will bridge the gap between the textbooks and the state of the art technology by reviewing recent publications. Each meeting of this course consists of student presentation of recent papers in the semiconductor and VLSI area. Depending upon the number of registered students, each student is expected to make a number of presentations of recent publications including conference papers, journal papers and patents.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Major Elective

**Advanced Semiconductor Fabrication Process**

Course Code	EWE8064	
Credits	Class hr	Lab hr
3	3	0

Semiconductor devices including memory and logic are the foundation of the electronics industry. The multitrillion dollar electronics industry is fundamentally dependent on the manufacture of semiconductor integrated circuits (IC). A fundamental knowledge of semiconductor materials, devices, and fabrication processes is the essential to understanding of modern versatile electronics. Recently, as the critical dimension of the devices shrinks and the nano-scale processes reach their limit, careful control of plasma is of great interest. Due to the importance, the understanding of advanced processes including lithography and patterning is essential. Especially, plasma has been widely used in industrial semiconductor processes, such as etching, deposition, and ashing. The main utility for plasma processing is the impinging of ions on the wafer and production of radicals by the plasma. This course will cover the basic principles of the low temperature plasma and the recent interest in plasma processing and lithography techniques.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## High-Speed and High-Density VLSI Circuit Design

Course Code	GAF8007	
Credits	Class hr	Lab hr
3	3	0

This course aims to convey knowledge of advanced concepts of circuit design for digital VLSI components in state of the art MOS technologies. Emphasis is on the circuit design, optimization, and layout of either a very high speed and high density, or low power circuits for use in applications such as microprocessors, signal and multimedia processors, memory and periphery. Special attention will be devoted to the most important challenges digital circuit designers face today and in the coming decade. They are being the impact of scaling, deep submicron effects, interconnect, signal integrity, power distribution and consumption, and timing. Extra focus will be given to the following topics: low power and low-voltage, process variations and robustness, and memory design in the nanoscale era. This will be reflected in both the lectures and the preferred projects.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## 3-Dimensional Image Processing

Course Code	EWE8035	
Credits	Class hr	Lab hr
3	3	0

The course 3D Image Processing consists of two parts; general processing and special processing. The course includes the necessary mathematical background and a brief description of existing 3D displays. In the first half, variety of 3D models and representation forms are considered, as well as their generation and transformation. Also, various processing methods and algorithms are presented including volume filtering, 3D Fourier transformation, surface detection, 3D (n-D) Bresenham line, correspondence problem and more. The second half is devoted to 3D displays and related special processing techniques which are not device independent and are featured by display classes (volumetric, stereoscopic, computational integral imaging, digital holography, etc.) Special attention is drawn to some important topics of 3D displaying, in particular, the depth map, intermediate parallaxes and tracking.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

H A N Y A N G U N I V E R S I T Y

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Department of  
**Energy Engineering**



Classification: Major Elective

## Special Topics Solar Cells

Course Code	EOE9001	
Credits	Class hr	Lab hr
3	3	0

Recently, renewable energy sources have been receiving great attention due to the increased world energy demand and the global warming. Especially, 3<sup>rd</sup> generation solar cells such as dye-sensitized solar cells, quantum dot solar cells, organic solar cells and perovskite solar cells have been deeply investigated due to their rather high energy conversion efficiency and low production cost. This class aims to teach fundamentals on principles and mechanisms of 3<sup>rd</sup> generation solar cells and to improve the energy conversion efficiency as well as the long-term stability. In particular, this course will cover basic theory, configuration, charge transport kinetics and characterization methods to give comprehensive understandings in this field. From basic concepts to applications, current state-of-the-art in this field will also be broadly discussed.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Special Topics in Energy Economics

Course Code	EOE9002	
Credits	Class hr	Lab hr
3	3	0

This course will provide the students with the background for understanding the electricity market. It includes the market overview, market operation and the market structure. It specially includes the general description of restructuring of electricity industry occurred in 1999. In addition, it will provide with the general explanations about the DSM (Demand Side Management) and DR (Demand Responding) in demand side and distributed energy system. It also includes introduction of the procedure how to develop the long term national electricity plan. In addition to the economic theories described above, system thinking modeling will be proposed for helping students to understand and analyze the complex electricity market. This course includes an overview of electricity market, modeling system thinking and analysis of the dynamics of Energy market.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

**Energy Technology Policy**

Course Code	<b>EOE9003</b>	
Credits	Class hr	Lab hr
3	3	0

This course is designed to strengthen student's capability to analyze the important messages and challenges of "Energy Security" and "Climate Change" we will face in the future. What will be the key driving force to change the world energy future and what kind of options do we have to address it? What are the most effective energy policies and strategies we should adopt and implement? With in-depth understanding and analysis of the late development of world energy outlook and pending international climate change issue (Durban Platform), each student is expected to have his own perspectives and strategies for a better energy future. This course covers climate change, energy policy, carbon capture, utilization and storage (CCUS), hydrogen economy and fuel cell technology etc.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

**Nanostructured Materials**

Course Code	<b>EOE9004</b>	
Credits	Class hr	Lab hr
3	3	0

This course is designed to provide students with advanced knowledge on nanoscience and nanomaterials. This course addresses nanotechnology and its engineering, particularly populated by chemical and materials engineering graduate students. "Traditional" and "state-of-the-art" topics such as various nanotechnologies and their applications will be broadly covered in this class, as well as nanomaterials for their specific energy applications. This course is intended to provide a unique educational experience for students who want to study fundamental nano-science and related energy science and engineering in the field of chemical and materials science engineering. Key points will be reviewed as needed. Moreover, a general chemistry, physics, physical chemistry and materials science background will be necessary, since auxiliary materials will be provided as needed.

**Frequency of offering:** Every Other Fall**Prerequisite:** Chemical and Materials Science Engineering

Classification: Major Elective

## Membrane Engineering

Course Code	EOE9008	
Credits	Class hr	Lab hr
3	3	0

Membrane processes have attracted great attention in recent years because of their numerous advantages, such as low energy requirement, small footprint, and easiness in scale up. In this class, we will discuss about basic principles and applications of membrane engineering. Students can comprehend fundamental equations, applications and the latest research trends of diverse applications of membrane engineering. Students are going to also talk about arguing points which need to be solved for commercialization of the applications. This class will be progressed by omnibus lectures and they will cover the following topics: Gas separation, water purification, desalination, membrane distillation, membrane crystallizer, membrane condenser, membrane emulsifier, membrane reactor and so on. Process Intensification strategy will be also considered.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Energy Seminar 2

Course Code	EOE9010	
Credits	Class hr	Lab hr
1	1	0

This course is to educate students in the basic aspects and on the most recent development of energy technology and climate change. The weekly Energy Seminar, chaired by professors of Energy Engineering and organized by the BK21 Plus Project, informs the Hanyang community about a wide range of energy and climate change issues and perspectives. The audience includes: faculty, graduate students, and undergraduate students, as well as energy professionals from the community. The Energy Seminar is held on Wednesday afternoons, 5:00-6:00, throughout the fall semester. The seminar is offered as a for-credit course for students (1 credit) and is also free and open to the public. Industrial, academic, and government leaders are invited to share their experiences and insights with students.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Greenhouse Gas Reduction and Technology Development Portfolio

Course Code		EOE9015
Credits	Class hr	Lab hr
3	3	0

This course is to enhance the capability to make proper strategy/policy for the clean energy technology R&D based on deep/wide understanding of the world energy situation of the future. It aims to enhance in-depth understanding on the 21st century energy challenges (energy security, climate change, and sustainable development) and analytic capability on long-term energy future and to enhance in-depth understanding on energy policies (Korea and key foreign countries) and implementing strategies. This course is designed to strengthen students' capability to analyze the important messages and challenges of "energy security" and "climate change" we will face in the future. Students will have opportunities to share their thinking about the key driving force to change the world energy future and what kind of options do we have to address it, and what are the most effective energy policies and strategies we should adopt and implement.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Energy Seminar 3

Course Code		EOE9016
Credits	Class hr	Lab hr
1	1	0

This course is to educate students in the basic aspects and on the most recent development of energy technology and climate change. The weekly Energy Seminar, chaired by professors of Energy Engineering and organized by the BK21 Plus Project, informs the Hanyang community about a wide range of energy and climate change issues and perspectives. The audience includes: faculty, graduate students, and undergraduate students, as well as energy professionals from the community. The Energy Seminar is held on Wednesday afternoons, 5:00-6:00, throughout the fall semester. The seminar is offered as a for-credit course for students (1 credit) and is also free and open to the public. Industrial, academic, and government leaders are invited to share their experiences and insights with students.

**Frequency of offering:** Every Semester

**Prerequisite:** None

Classification: Major Elective

## Advanced Electrochemistry

Course Code	EOE9020	
Credits	Class hr	Lab hr
3	3	0

Electrochemical energy storage and conversion devices are of utmost importance in order to address the global concerns on the climate changes of the Earth caused by the use of fossil fuels. Recently, along with the rapid progress in the electrical engineering and information technology, these technologies have been used in power sources for portable electronic devices, electric vehicles and energy storage systems. However, these energy devices should be further advanced to meet the requirements of the aforementioned emerging applications. One of the efficient ways is to understand the underlying reaction chemistry of these electrochemical energy storage and conversion devices. In this class, students will study the advanced materials for energy conversion and storage, the design and synthesis of energy storage materials, performance evaluation and their applications.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Materials for Energy Renewal

Course Code	EOE9031	
Credits	Class hr	Lab hr
3	3	0

Domestic and international energy issues and the roles of renewable energy sources will be first briefly introduced. The fundamentals and basic principles of such energy conversion and storage devices as dye-sensitized and organic solar cells, fuel cells and secondary batteries will then be taught. Mass transport through solid materials and its applications to the energy conversion and storage devices will be emphasized. This course introduces the various classes of materials that are presently exploited for the development of lithium batteries and fuel cells. The students will learn the properties and characteristics of electrode and electrolyte materials that are presently considered the most appropriate for the progress of lithium batteries and fuel cell technologies. The students will be challenged in their critical thinking for analyzing the materials in view of their applications in various areas of these presently evolving technologies. They will learn the various approaches used to improve the performance of these materials and the experimental techniques to investigate them.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Energy Nanotechnology

Course Code	EOE9033	
Credits	Class hr	Lab hr
3	3	0

This course addresses nanotechnology and its engineering, particularly populated by chemical and materials engineering graduate students. "Traditional" and "state-of-the-art" topics such as various nanotechnologies and their applications will be broadly covered in this class, as well as nanomaterials for their specific energy applications. This course is intended to provide a unique educational experience for students who want to study fundamental nano-science and related energy science and engineering in the field of chemical and materials science engineering. Key points will be reviewed as needed. Moreover, a general chemistry, physics, physical chemistry and materials science background will be necessary, since auxiliary materials will be provided as needed.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Chemistry, Physics, Physical Chemistry and Materials Science

Classification: Major Elective

## Membrane Engineering 2

Course Code	EOE9035	
Credits	Class hr	Lab hr
3	3	0

Membrane processes have attracted great attention in recent years because of their numerous advantages, such as low energy requirement, small footprint, and easiness in scale up. In this class, we will discuss about basic principles and applications of membrane engineering. Students can comprehend fundamental equations, applications and the latest research trends of diverse applications of membrane engineering. Students are going to also talk about arguing points which need to be solved for commercialization of the applications. And this class will be progressed by omnibus lectures and this class will be covered followings: Gas separation, water purification, desalination, membrane distillation, membrane crystallizer, membrane condenser, membrane emulsifier, membrane reactor and so on. Process Intensification strategy will be also considered.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Transport Phenomena Through Solid Materials

Course Code	EOE9037	
Credits	Class hr	Lab hr
3	3	0

Basic principles and fundamentals on mass transport phenomena through polymers will be introduced. In particular, diffusional transport of neutral molecules through solid state polymer materials will be emphasized. The diffusional transport is commonly characterized by permeability, defined as a product of the diffusion and the solubility coefficients. Therefore the diffusion coefficient, a kinetic parameter, will be introduced first, and then applied for gas diffusion through polymeric materials. The dissolution behavior of gas into polymer will also be introduced, which can be commonly characterized by the solubility coefficient, defined as the ratio of the amount of gas dissolved in the polymer to the weight of the polymer. In addition, facilitated transport concept will also be introduced to enhance the transport of a specific compound, which is essential for membrane separation. Finally applications of both the solution-diffusion and facilitated transport behavior to real separation systems such as olefin/paraffin mixtures and CO<sub>2</sub> removal from flue gas will be introduced.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Energy Storage Materials

Course Code	EOE9038	
Credits	Class hr	Lab hr
3	3	0

This course introduces the various classes of energy materials that are presently exploited for the development of secondary batteries and related devices. The students will learn the properties and characteristics of energy related materials that are presently considered the most appropriate for the progress of secondary battery technologies. They will be challenged in their critical thinking for analyzing the materials in view of their applications in various areas of these presently evolving technologies. They will learn the various approaches used to improve the performance of these materials and the experimental techniques to investigate them. Li-S batteries and Li-air batteries have been considered as a candidate power sources for electrical vehicles due to their extremely high theoretical energy density. Na-ion batteries are considered worthy of intensive investigation for large battery applications, since the sodium reserves are easily accessible. The students will learn the next-generation Li-ion batteries, e.g. Li-S batteries, Li-air batteries, and Na-ion batteries.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Biomolecular Materials for Nano-Energy Technology

Course Code	EOE9042	
Credits	Class hr	Lab hr
3	3	0

Marching with the recent energy research trends for the interdisciplinary nano-bio-energy, this course will provide the basic knowledge required for the energy engineering students and introduce the recent literatures that describe the role of functional biomolecules and its application to the practical devices. The ultimate goal of this course is to enhance student's level of understanding on the bio-inspired technologies and motivate the students to have the creativity for the application to energy engineering. This course focuses on the chemistry and chemical structure-property relationships of biologically derived materials in the application to nano-energy technology. Biochemistry, only particularly relevant to energy engineering, will be covered. The course provides case studies of the recent research literatures on the role of bio-molecules in synthesizing and assembling functional materials and the application to the practical devices. Class contents also include the highly efficient biological energy conversion and storage ways to introduce bio-inspired novel energy conversion and storage mechanisms as clean and renewable energy systems.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Electrochemistry of Energy Storage / Conversion Devices

Course Code	EOE9044	
Credits	Class hr	Lab hr
3	3	0

This course is designed for graduate students who are interested in the scientific challenges of electrochemical energy storage and conversion devices. Technical breakthrough is highly needed to fully address the technical issues of the electrochemical energy devices. One of the most efficient ways is to understand the basic reaction chemistry of these energy devices. In this regard, this lecture will start from the fundamental electrochemistry, and thermodynamics and kinetics of electrode process, with emphasis on and advanced electrochemical energy devices including batteries, fuel cells, supercapacitors and other electrochemical energy conversion and storage devices. In particular, this lecture will focus on the electrochemical reactions occurred in these devices as a tool for understanding the operation principles and detailed reaction mechanisms.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topics in R&D Skill

Course Code	EOE9046	
Credits	Class hr	Lab hr
3	3	0

Through this course, graduate students can fully understand the necessities and objectives of the researches in our life. By suggesting the approach methods to the current issues and the way of analyzing the problem, the graduate student can develop the ability of thinking and improving the problems. In this global age, this class has an objective for the graduate students in enhancing the English conversation skill and presentation skill. The key issues in R&D implementation are how to obtain and to utilize knowledge and experience and how to produce new knowledge. In this lecture, the students shall learn how to obtain and to manage the knowledge and experience and to make valuable information from his/her results. For these purposes, scientific communication skills such as making charts, graphs, and tables will be lectured and practiced.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Membrane Processes

Course Code	EOE9050	
Credits	Class hr	Lab hr
3	3	0

Membrane processes have attracted great attention in recent years because of their numerous advantages, such as low energy requirement, small footprint, and easiness in scale up. In this class, we will discuss about basic principles and applications of membrane engineering. Students can comprehend fundamental equations, applications and the latest research trends of diverse applications of membrane engineering. Students are going to also talk about arguing points which need to be solved for commercialization of the applications. And this class will be progressed by omnibus lectures and this class will be covered followings: Gas separation, water purification, desalination, membrane distillation, membrane crystallizer, membrane condenser, membrane emulsifier, membrane reactor and so on. Process Intensification strategy will be also considered.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topics in R&D Leadership - R&D System

Course Code	EOE9051	
Credits	Class hr	Lab hr
3	3	0

Through this course, graduate students can fully understand the necessities and objectives of the researches in our life. By suggesting the approach methods to the current issues and the way of analyzing the problem, the graduate student can develop the ability of thinking and improving the problems. In this global age, this class has an objective for the graduate students in enhancing the English conversation skill and presentation skill. The key issues in R&D implementation are how to obtain and to utilize knowledge and experience and how to produce new knowledge. In this lecture, the students shall learn how to obtain and to manage the knowledge and experience and to make valuable information from his/her results. For these purposes, scientific communication skills such as making charts, graphs, and tables will be lectured and practiced.

**Frequency of offering:** Every Spring

**Prerequisite:** None

Classification: Major Elective

## Membrane Technology for Clean Energy

Course Code	EOE9052	
Credits	Class hr	Lab hr
3	3	0

Membrane processes are considered potentially better for the environment since the membrane approach require the use of relatively simple and non-harmful materials. In fact, most of membrane processes do not contain treatments with harmful solvents or large energy consumption, hence, membrane technology is widely recognized as a green process and a key technology for process intensification. However, the membrane fabrication process itself is far from being green and sustainable. For instance, to prepare membranes using phase inversion technique, significant volumes of harmful solvents such as DMF, NMP, and DMAc are commonly used. Such solvents are known to be highly eco-toxic as they can bio-accumulate. In this regard, we will discuss the benefit of membrane engineering in terms of environmental issues and environmental endeavors and regulations around the world, particularly in the US and Europe, which are becoming increasingly more stringent to provide membrane process with sustainability.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

## Special Topic in Advanced Energy Materials

Course Code	EOE9053	
Credits	Class hr	Lab hr
3	3	0

Energy storage and conversion technology are important technologies which enables the energy liberated in an electrochemical reaction to be converted directly into electric energy. These technologies have been used in power sources for portable electronic devices, electric vehicles and energy storage systems. The Lithium ion batteries (LiIBs) have attracted, during the last four decades, the attention of researchers from different fields, due to their use in practical applications such as Laptops, cellphones, toys, etc. This attention has been renewed recently, since LiIBs are promising for large scale energy storage applications such as electric vehicles and grid storage applications. Recently, growing concerns over the depletion of fossil fuels and the environment has led to global efforts to secure sustainable energy supplies. While Li-ion batteries have served as one of the most reliable energy storage thus far, Li-air and Li-S batteries have attracted a considerable amount of interest as an alternative to conventional Li-ion batteries. In this class, we will study on the advanced materials for energy conversion and storage, the design and synthesis of energy storage materials, performance evaluation and their applications.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

## Electrochemical Cation Storage Materials

Course Code	EOE9054	
Credits	Class hr	Lab hr
3	3	0

This course is designed for graduate students who are interested in the scientific challenges of electrochemical energy storage devices including rechargeable batteries and electrochemical capacitors. Recently, electrochemical energy storage materials have gained much attention as power sources for electric vehicles and large-scale energy storage units. In order to meet the requirements of the aforementioned applications, the technology of the electrochemical energy storage devices should be further advanced. One of the most promising ways is to find new battery chemistry that surpasses the currently used lithium ion battery technology. In order to explore new battery chemistry, it is of utmost importance to understand the physics and chemistry of cation storage reactions into host materials. In this regard, this lecture will start from the fundamental thermodynamics and kinetics of electrochemical cation storage reactions, with emphasis on and advanced electrochemical energy devices including batteries, supercapacitors and other electrochemical energy storage devices.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

**Mathematical Modeling for Electrochemical Process**

Course Code		EOE9055
Credits	Class hr	Lab hr
3	3	0

This course is designed to provide a basic understanding on mathematical modeling of systems in electrochemical reaction based on the ideas of electrochemistry and allow students to apply its techniques. Students are required to learn electrochemistry and numerical analysis to take this class. Topics include an introduction of electrode kinetics, transport phenomena, infinitely dilute solution, convective transport problems, primary current distribution, thermodynamics in terms of electrochemical potential, electric potential, effect of migration on limiting currents, concentration overpotential, dimensional analysis, and AC impedance. In the end of class, students can enhance skills developed in mathematical modeling. Students will have a term project and choose topics related to their ongoing research. Students should be familiar with basic concepts on electrochemistry and numerical analysis.

**Frequency of offering:** Every Other Fall**Prerequisite:** Electrochemistry, Numerical Analysis

Classification: Major Elective

**Materials Science and Engineering of Carbon**

Course Code		EOE9056
Credits	Class hr	Lab hr
3	3	0

This course aims to give comprehensive information firstly on fundamental science on preparation and characterization of various carbon materials, and secondly on engineering and applications of various carbon materials, on the basis of the same basic concept, i.e., classifications based on carbon families and nanotextures. This course addresses carbon materials science, particularly populated by energy, chemical and materials engineering students. In addition to “traditional carbon materials” topics such as graphite, and new carbon materials such as nanocarbons will be broadly covered in this class. Each carbon material will be discussed in detail about its intrinsic properties, and the processes to utilize carbon materials in various applications such as energy storage devices, semiconductors, displays and membranes will also be introduced in this class.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

Classification: Research Elective

## **Energy Engineering Scientific Research and Writing Methodology**

Course Code	<b>EOE9058</b>	
Credits	Class hr	Lab hr
3	3	0

This course will be given by four professors at Department of Energy Engineering. This course will cover research ethics, scientific research methodology, scientific paper writing, and professional presentation skills. Introduction of patents and how to use them for research would also be given in the lecture. In detail, this course will cover the following topics: “What is a patent?”, “Why is it important for researchers?”, “Where and how can we search patents?”, “Where and how can we search patents?”, “How is patent analysis helpful for your research?”, “What is the original patent?”, “How can we make strong patents?”, “How to use software for scientific paper writing such as Endnote”, and finally, “How to prepare your posters or power point presentations”.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Industrial Engineering**



Classification: Major Elective

## Modeling and Analysis of Manufacturing Systems

Course Code		INE8043
Credits	Class hr	Lab hr
3	3	0

This course is an introductory level course in modeling and analysis of manufacturing systems. Emphasis will be placed on development of analytical models and solution algorithms of manufacturing systems. The course includes the following topics: (1) Product design and process planning such as code scheme and part family formation, (2) Production system design such as capacity planning, production cell formation and part type selection, facility layout, automated guided vehicle, and automatic storage/retrieval system, (3) Production planning such as aggregate production planning, product mix planning, and assembly line, (4) Operational planning such as single, parallel machine scheduling, flowshop scheduling and jobshop scheduling, schedule generation, and (5) Production control such as machine setup and sequencing.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Compulsory

## Design and Operation of Flexible Manufacturing Systems

Course Code		INE9070
Credits	Class hr	Lab hr
3	3	0

A flexible manufacturing system (FMS), which pursues both the productivity and flexibility at the same time, is an automated manufacturing system consisting of a set of identical and/or complementary numerically controlled machines which are connected through an automated material handling and storage system, and all controlled by an integrated computer system. In this course, various design and operation problems occurred in flexible manufacturing systems are considered. The topics to be dealt with in this course are (1) Flexibility: Overview, Classification and Relations, (2) Economic Justification: Overview and Methods, (3) FMS Design: Overview, Performance evaluation and Generative models (routing, capacity and equipment optimization), and (4) Pre-release Planning: Overview, Batching and System setup.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Operations Management, Operations Research

Classification: Major Elective

**Data Mining**

Course Code		INE9071
Credits	Class hr	Lab hr
3	3	0

Data mining is one of the modern statistical processes which result in the discovery of new patterns and rules in data sets in the tasks of prediction, classification, recommendation, and so forth. This course pertains to how to understand the concepts of several data mining techniques and to perform data mining analysis. The topics of the course will include Bayesian decision processes, decision trees, cluster analysis, discriminant analysis, factor analysis, neural networks, support vector machines, and so forth. Modern statistical software such as MATLAB/R along with the java/C languages, as needed, will be used to demonstrate the techniques. The aim of this course is to enable students to understand various kinds of data mining techniques and apply them to real-life data sets.

**Frequency of offering:** Every Other Spring**Prerequisite:** General Statistics, Computer Programming

Classification: Major Elective

**Optimal Location Logistics**

Course Code		INE9072
Credits	Class hr	Lab hr
3	3	0

This course gives graduate students an understanding of advanced topics in location logistics to select the optimal locations of industrial plants and distribution centers through analytical modeling of the costs, transportation, utilities, labor supply and other cost components. Lectures emphasize on construction and analyzing mathematical models related to location logistics. The course includes the following topics: (1) Planar single-facility location problems such as Euclidean Distance Minisum location problem, Rectilinear Distance Minisum location problem, Euclidean Distance Minimax location problem, and Rectilinear Distance Minimax location problem. (2) Planar multiple-facility location problems such as Rectilinear Distance Minisum location problem, Squared Euclidean Minisum location problem, and Euclidean Minisum location problem. (3) Tree network location problems such as 1-median, 1-center, Covering, n-center problem. (4) Cyclic network location problem such as 1-median, 1-center, Covering, n-center, n-median problem. (5) Advanced discrete location model such as Incapacitated Facility Location Problem and Capacitated Facility Location Problem.

**Frequency of offering:** Every Other Year**Prerequisite:** None

Classification: Major Elective

## Statistical Learning

Course Code	INE9089	
Credits	Class hr	Lab hr
3	3	0

Statistical Learning pertains to important statistical methods and principles as regards to data analysis. It consists of two parts: the first part deals with classical statistical frameworks such as distribution, parameter estimation, linear models, EM algorithm, data reduction, and so on; the second part deals with Bayesian approaches such as Bayes decision, prior distribution, and so forth. Modern statistical software such as MATLAB/R/Winbugs, as needed, will be used to demonstrate the techniques. Before the Final Exam period, students are required to perform final projects in which real-life research issues and datasets arise as regards to the discussed methods. The aim of this course is to enable students to understand various kinds of statistical techniques and apply them to real-life data sets.

**Frequency of offering:** Every Other Spring

**Prerequisite:** General Statistics, Computer Programming

Classification: Major Elective

## Stochastic Process

Course Code	INE9102	
Credits	Class hr	Lab hr
1	1	0

Manufacturing & service systems typically have random components to their behavior such as the demand for products and services. Students will learn quantitative methods which are useful in analyzing, designing and operating stochastic systems – particularly, manufacturing and service systems. Much of attention will be focused on understanding, managing and reducing variability for inventory production and service systems. Specific topics that students will discuss in the course are as follows: (1) Motivating Example such as the Newsvendor Problem, (2) Discrete Time Markov Chain, (3) Poisson Process, (4) Continuous Time Markov Chain, and (5) Queueing Theory.

**Frequency of offering:** Every Other Spring

**Prerequisite:** Basic Probability, Basic Statistics

Classification: Major Elective

## Computer-Oriented Statistics

Course Code	MAT9019	
Credits	Class hr	Lab hr
3	3	0

Computer-oriented statistics is the interface tool between statistical inference from statistics and computing from computer science. This course will discuss several topics of basic techniques in computational statistics and teach the implementation and application of those techniques. The class starts with teaching some modern statistical/computational SW tools such as MATLAB, R, Python and so forth. The topics will include quick sorting, bisection, least-squares variants (ridge, lasso, and others), eigenvalues, page rank algorithm, SVD, splines, optimization, Gibbs sample, Metropolis-Hasting algorithms, Hidden Markov chains, and so forth. Statistical software such as MATLAB and R will be used for the demonstration of the techniques. The aim of this course is to enable students to understand the underlying principles of several techniques in computational statistics and know how to apply them in real data sets.

**Frequency of offering:** Every Other Fall

**Prerequisite:** General Statistics, Computer Programming

H A N Y A N G   U N I V E R S I T Y

Department of  
**Information Systems**



Classification: Major Elective

## Introduction to Information Systems

Course Code	ITM0017	
Credits	Class hr	Lab hr
3	3	0

Globalization of business and growth of Internet have recast to role of information systems in business and management. Strategic use of information systems is regarded as an essential capability to achieve competitive advantages. Therefore, better understanding of information systems is helpful for students who are interested in working and studying in this field. This course offers a comprehensive overview of information systems. Upon successfully completing this course, students will be able to understand how information systems can manage business process and organization. Specifically, this course will cover the following topics: Basic concepts of information systems, Key enabling technologies for information systems, Business application, Development process of information systems, and Managerial challenges of IT and information systems.

**Frequency of offering:** Every Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Materials Science  
and Engineering**



Classification: Major Elective

**Special Issues on Nanoscale Characterization**

Course Code		MAE6016
Credits	Class hr	Lab hr
3	3	0

Nanoscale characterization plays important roles for understanding fundamental properties of nanomaterials and developing new material systems and related devices. This course is designed both to provide the students with the basic principles and concepts of materials characterization and chemical analysis and, on the basis of the fundamental knowledge, to deal with more recent and advanced issues in nanoscale characterization. The topics include basic principles of characterization, instrumentation development and application platform to image and probe structural, chemical, electrical, and optical characterizations at nanometer scale. As for microscopic techniques, scanning probe microscopies (AFM, STM, EFM, etc.) and electron microscopies (SEM, TEM, and SAM) will be introduced. In addition, the major surface analysis techniques, such as XPS, AES, SIMS and RBS, and the other spectroscopic techniques (micro-PL, micro-Raman, and FTIR) will be covered and the recent advances in enhancing the resolution and new capabilities will be highlighted.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

**Behaviors of Materials at Elevated Temperature**

Course Code		MAE8075
Credits	Class hr	Lab hr
3	3	0

This course provides a better understanding of the fundamentals of high-temperature plastic deformation, Creep, including the mechanisms, phenomena and creep damages as applies to pure metallic metals and simple alloys. It should be noted that Creep is “time-dependent” deformation of materials occurring at constant stress and constant temperature. The aim of this subject is to extend the knowledge of mechanics, metallurgy and material science into plastic deformation and creep of materials. A series of the lectures provides the comparison of individual theories of plasticity and creep applicable into the practice. In practice, the lecture contain the following topics: Dislocation and diffusion theories, Phenomenological approach, Analysis of activation energy, Factors influencing activation energy, Stress dependence of creep, Five-Power-Law creep, Diffusion Creep, Three-Power-Law creep, Superplasticity, Creep mechanisms, Creep behavior of alloys, and Creep fracture.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Mechanical Convergence  
Engineering**



Classification: Major Elective

**Advanced Stress Analysis I**

Course Code	AUE8023	
Credits	Class hr	Lab hr
3	3	0

This course deals with linear elasticity theory, which is a fundamental subject in structural analysis and engineering design, often with the aid of numerical analysis. Elasticity theory is the mathematical study of how solid objects deform and become internally stressed under prescribed loading and boundary conditions. The fundamental assumptions of linear elasticity are infinitesimal or small strains, and linear relationships between the components of stress and strain. These assumptions are reasonable for many engineering materials and engineering design. The objective of this course is for graduate students to have application ability of the knowledge which has been learned to various application fields and their researches. This course will cover the method of solution in two or three dimensional problems based on the mathematical theory. Numerical methods are also introduced for solving some problems which cannot be solved theoretically. This course requires the knowledge of mechanics of materials.

**Frequency of offering:** Every Spring**Prerequisite:** General Physics, Mechanics of Materials

Classification: Major Elective

**Advanced Stress Analysis II**

Course Code	AUE8024	
Credits	Class hr	Lab hr
3	3	0

This course deals with nonlinear elasticity theory, which is an advanced subject in structural analysis and engineering design, almost with the aid of numerical analysis. Nonlinear elasticity theory is the mathematical study of how solid objects deform and become internally stressed under prescribed loading and boundary conditions. The fundamental assumptions of nonlinear elasticity are large deformation or finite strains, and nonlinear relationships between the components of stress and strain. The objective of this course is for graduate students to have application ability of the knowledge which has been learned to various application fields and their researches. This course will mainly cover the method of solution in buckling, stress-stiffening, plasticity, creep, contact problems. And numerical methods such as finite element method are also introduced for solving nonlinear structural problems. This course requires the knowledge of mechanics of materials and advanced stress analysis I.

**Frequency of offering:** Every Other Fall**Prerequisite:** Mechanics of Materials, Advanced Stress Analysis I

Classification: Major Elective

## Advanced Aerosol Science and Technology

Course Code	GAL8025	
Credits	Class hr	Lab hr
3	3	0

An aerosol, by definition, means a collection of solid or liquid particles suspended in a gas. The aerosols are formed by the conversion of gases to particles or by the disintegration of liquids or solids. They may also result from the resuspension of powdered material or the breakup of agglomerates. The particles suspended in the air can influence visibility and climate. Moreover, since the airborne particles are respirable, they can affect people's health and life quality. As a result, many countries have regulations or standards related to air quality, for example, PM10 standard or PM2.5 standard. It is therefore important to understand the behavior of aerosol particles. The purpose of this course is to introduce students to the advanced aerosol technology. The topics of this course are advanced particle mechanics; sampling and concentration measurement; aerosol particle filtration; aerosol coagulation; aerosol charging and neutralization; aerosol condensation and evaporation; and optical properties of aerosol particles.

**Frequency of offering:** Every Other Fall

**Prerequisite:** General Physics, Fluid Mechanics, Particle Technology

Classification: Major Elective

## Advanced Optical Engineering

Course Code	MEE7014	
Credits	Class hr	Lab hr
3	3	0

Recently, optics have played an increasing role in a wide range of applications encompassing uses in the laboratories as well as in the industrial field due to many advantages such as non-contact and remote operation, fast scan, and high accuracy. In this lecture, to understand the optical phenomena and learn the application capabilities of these optical phenomena in mechanical engineering, basic principles of optics, description of optical phenomena and their application to mechanical engineering will be introduced. The topics are imaging by mirror and lens, mirror and lens equations, electro-magnetic characterizations of light, superposition of wave, interference and its applications to interferometry, holography and holographic interferometer, diffraction and Fourier optics, optical signal processing, and laser applications. This course is open to undergraduate students as well.

**Frequency of offering:** Every Fall

**Prerequisite:** None

Classification: Major Elective

**Radiative Heat Transfer**

Course Code	MEE8026	
Credits	Class hr	Lab hr
3	3	0

Electromagnetic radiation is continuously emitted from all substances because of the molecular and atomic agitation associated with their internal energy. At a temperature higher than 0K, ions or molecules begin to vibrate and emit radiation, which is classified as thermal radiation and detected as heat or light. The wavelength range considered in thermal radiation corresponds to UV light, visible light, and infrared. For the most part, thermal radiation may be based on the classical electromagnetic wave theory. However, important effects such as the spectral energy distribution from a body and the spectral behavior of radiative properties of gases can only be explained by quantum mechanics. The purpose of this course is to introduce students to the thermal radiation heat transfer. The topics of this course are blackbody radiation, radiation properties of strongly absorbing media, radiation exchange between two surfaces, radiation exchange in enclosures, radiation transport in participating media, and radiation exchange in enclosures with participating media.

**Frequency of offering:** Every Other Fall**Prerequisite:** Heat Transfer

Classification: Major Elective

**Ultrasonic Engineering**

Course Code	PME8025	
Credits	Class hr	Lab hr
3	3	0

The basic theory of ultrasonic wave and the applications to the non-destructive evaluation will be introduced. The theory covers the generation and propagation mechanisms of typical ultrasonic waves in solids, such as longitudinal wave, transversal wave, surface wave, and plate wave. Also various phenomena in the wave propagation, such as reflection, refraction, diffraction, and attenuation are included. This lecture will be constructed with four major categories: (1) one dimensional analysis of ultrasonic wave propagation based on the one dimensional wave equation derived from the solid mechanics and dynamics, (2) three dimensional analysis of ultrasonic wave propagation with tensor and potential theory, (3) ultrasonic nonlinear phenomena, and (4) techniques for ultrasonic non-destructive testing. In the applications, conventional methods for the defect inspection and the material evaluation are introduced with several worldwide new technologies.

**Frequency of offering:** Every Spring**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Mechanical Engineering**



Classification: Major Elective

**Advanced Dynamics**

Course Code		DME8045
Credits	Class hr	Lab hr
3	3	0

How to derive the equations of motion of a dynamical system is an essential step for an engineer to estimate the system behavior and to design the system. In this course, fundamental concepts on kinematics, mass, force and energy functions are first introduced. Especially, a definition of angular velocity and four fundamental theorems to obtain kinematic information will be discussed. Then a method of deriving equations of motion, often called the Kane's method, will be discussed. This method is much more efficient and consistent than other methods like the Lagrange's equation and virtual work principle. This method is also very effective to derive equations of motion for structural systems. The undergraduate course 'Dynamics' is a prerequisite for this course.

**Frequency of offering:** Every Spring**Prerequisite:** Dynamics

Classification: Major Elective

**Optimization Techniques**

Course Code		DME8059
Credits	Class hr	Lab hr
3	3	0

In recent years, numerical optimization methods have matured into a powerful and efficient design tool for a wide variety of engineering applications. This course provides a broad overview of the concept of numerical optimization and the associated algorithms for line search, unconstrained optimization, sequential unconstrained minimization techniques including penalty function methods and the augmented Lagrange multiplier method, direct constrained optimization methods including sequential linear programming, the method of feasible directions, the generalized reduced gradient method, the modified feasible directions method, and sequential quadratic programming, approximations techniques including design variable linking, the reduced basis concept, constraint deletion, and sensitivity of the optimum design to problem parameters and duality. Also, a variety of applications are described to indicate the breadth of design problems that can be solved with this optimization tool.

**Frequency of offering:** Every Spring**Prerequisite:** None

Classification: Major Elective

## Advanced Heat Transfer

Course Code	<b>MEE8003</b>	
Credits	Class hr	Lab hr
3	3	0

Advanced Heat Transfer is the Mechanical Engineering Department's core graduate course on heat and mass transfer. This course is open to students from all areas of engineering, although an undergraduate background in heat transfer will be assumed. Topics to be covered include: conservation laws and conduction, particularly transient heat transfer. Theoretical approximation of temperature evolution as a function of temperature will be explored to characterize time-dependent conduction heat transfer under various boundary conditions. Class topics are dealt with in greater depth, and students are encouraged to leave this course with a better appreciation of the underlying fundamentals and with improved analytical skills. Mass transfer by diffusion and convection will also be covered and the analogy between heat and mass transfer will be emphasized. Lastly, students will be required to present term projects, which are closely related to heat and mass transport phenomena in eco-friendly technology areas, at the end of the semester.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Thermodynamics, Fluid Mechanics, Heat Transfer

Classification: Major Elective

## Convection Heat Transfer

Course Code	<b>MEE8025</b>	
Credits	Class hr	Lab hr
3	3	0

The solution to a wide variety of heat transfer problems can be consolidated under a fairly limited number of methodologies. Such problems include finding surface temperature distributions around gas turbine blade, the temperature distribution on airfoils in hypersonic flight, blood and arterial wall temperatures during hypothermia episodes, etc. The consolidating feature is the existence of a thin boundary layer that separates the bulk free stream fluid properties from those of the surface. This boundary layer provides most of the resistance to heat transfer, and an understanding of its properties leads to an ability to solve this wide range of problems both analytically and numerically. Thus, this course focuses on the methods used to evaluate the resistance of boundary layers to heat transfer.

**Frequency of offering:** Every Spring

**Prerequisite:** Thermodynamics, Fluid Mechanics, Heat Transfer

Classification: Major Elective

## Particle Technology

Course Code	<b>MEE8063</b>	
Credits	Class hr	Lab hr
3	3	0

In the air, there are many kinds of particles, and these particles suspended in the air can influence visibility and climate. Moreover, since the airborne particles are respirable, they can affect people's health and life quality. By definition, aerosol is the collection of solid or liquid particles suspended in a gas medium. Aerosol technology plays a key role in many different fields including atmospheric sciences and air pollution, industrial production of pigments, filters, and specialty metal powders, industrial hygiene, contamination control in the microelectronics and pharmaceuticals industries, etc. This course will cover basic knowledge of properties, behavior, and measurement of airborne particles, that is, aerosols. The topics of this course are introduction to aerosol particles, properties of gases, elementary particle mechanics, inertial separation of aerosol particles, particle size statistics, Brownian diffusion of aerosol particles, coagulation of aerosol particles, condensation and evaporation of aerosol particles, and electrical properties of aerosol particles.

**Frequency of offering:** Every Spring

**Prerequisite:** General Physics, Fluid Mechanics

Classification: Major Elective

## Transport Phenomena in Fuel Cells

Course Code	<b>MEE9085</b>	
Credits	Class hr	Lab hr
3	3	0

This course serves as an introduction to heat & mass transfer as well as electrochemical kinetics in fuel cells with a vast majority of emphasis on the polymer electrolyte fuel cells. The various types of fuel cells from components to systems are also introduced to give students brief ideas how fuel cells work and its roles in the 21st H2 economy. Issues of specific interest to mechanical engineers, including water management and heat and mass transfer will be dealt with in greater depth. The goal of this study is to apply fundamentals of electrochemistry, thermodynamics, fluid dynamics, and heat transfer, as appropriate, to examine various issues of interest to mechanical engineers. In addition, students are strongly encouraged to articulate the basic fundamentals of electrochemistry in terms of electrochemical potential, thermodynamics, and kinetics of electrochemical systems.

**Frequency of offering:** Every Fall

**Prerequisite:** Thermodynamics, Fluid Mechanics, Heat Transfer

H A N Y A N G   U N I V E R S I T Y

Department of  
**Nanoscale Semiconductor  
Engineering**



Classification: Major Elective

## Seminar on the Advanced Topics of Analog Circuit Design

Course Code		ENE9070	
Credits	Class hr	Lab hr	
3	3	0	

In order to design an analog and mixed signal circuit, a deep understanding of the basic building blocks such as amplifiers, timing circuits, feedback circuits, filtering circuits, and power-related circuits is required. Assuming that the student has knowledge on basic microelectronics and semiconductor physics, various topics of analog circuit design will be covered with a textbook. Furthermore, the most recent research articles of top-tier journals (IEEE Journal of Solid-State Circuits, IEEE Transactions on Circuits and Systems – I and –II, IEEE Transactions on Power Electronics) and conferences (IEEE International Solid-State Circuits Conference, IEEE Symposium on VLSI Circuits, IEEE Custom Integrated Circuits Conference, IEEE Asian Solid-State Circuits Conference, IEEE European Solid-State Circuits Conference) will be discussed. The students have to present the contents of at least one research article of top-tier journals and conferences in English. This lecture is intended for graduate students majoring in analog circuit design or related research fields.

**Frequency of offering:** Every Spring

**Prerequisite:** Microelectronics (Undergraduate)

Classification: Major Elective

## VLSI Circuit Design

Course Code		NSE8002	
Credits	Class hr	Lab hr	
3	3	0	

This course aims to convey knowledge of advanced concepts of circuit design for digital IC components in state of the art MOS technologies. Emphasis is on the circuit design, optimization, and layout of either very high density or low power circuits for use in applications such as microprocessors, signal and multimedia processors, memory and periphery. Special attention will be devoted to the most important challenges digital circuit designers face today and in the coming decade. They are being the impact of scaling, deep submicron effects, interconnect, signal integrity, power distribution and consumption, and timing. Extra focus will be given to the following topics: low power and low-voltage, process variations and robustness, and memory design in the nanoscale era. This will be reflected in both the lectures and the preferred projects.

**Frequency of offering:** Every Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Natural Resources  
and Environmental  
Engineering**



Classification: Major Elective

## Biomass Engineering

Course Code	MPE7007	
Credits	Class hr	Lab hr
3	3	0

An expanding world's population and a desire for a greater standard of living provoked a day-by-day increase in energy demand. The diminishing fossil-fuels reserves and deleterious environmental consequences of exhaust gases, encouraged researcher to explore alternative renewable fuel options. Biofuels prepared from renewable resources such as biomass could be an effective and sustainable alternative. Bioenergy is gaining a lot of attention to overcome these tremendous demands. This course explores different technologies for processing biomass as renewable energy resource contributing to security in energy supply and reducing the environmental impact of the energy systems. It will provide an in-depth understanding of the processes and technologies for production of energy, chemical and material products based on biomass processing. It includes the processes and technologies for producing the main types of biofuels, namely bioethanol, biohydrogen, biomethane and biodiesel using selective processes such as pyrolysis, gasification, fermentation and anaerobic digestion.

**Frequency of offering:** Every Spring

**Prerequisite:** Environmental Engineering

Classification: Major Elective

## Advanced Groundwater Contamination and Remediation

Course Code	MPE7008	
Credits	Class hr	Lab hr
3	3	0

The contamination of ground water due to inorganic and organic pollutants is a global concern. This is particularly important when surface water (river/lake) is reported to be more polluted and over-used globally. Once contaminated, the revival of ground water is difficult as ground water being very cold causes slow and/or no bacterial breakdown. Moreover, recharge of ground water might take 100's or 1000's of years. This course covers the fundamentals of solid-water interfacial chemistry dealing with various interfacial phenomena both in engineered systems and natural environments. The topics in the course include introduction of pollutants, importance of groundwater and its contamination, sorption process, examples of interfaces, interfacial phenomena and thermodynamics in chemical system, introduction to surface sorption, MinteqA2, chemical thermodynamics, sorption kinetics, sorption kinetics and modeling, electrical double layer (EDL) and sorption, cation and anion sorption, sorption modeling.

**Frequency of offering:** Every Fall

**Prerequisite:** Basics of Chemistry

Classification: Major Elective

## Well Testing

Course Code	MPE8039	
Credits	Class hr	Lab hr
3	3	0

This course introduces the purpose of well testing and the basic interpretation methodology. The theory and fundamental equations, as well as various understanding analytical solutions are covered before introducing specific analysis techniques for homogeneous oil and gas reservoirs. Non-homogeneous situations and more advanced topics are also covered. Assumptions made in deriving equations and solutions and models used in test interpretation are stressed. The course covers well test objectives and fundamental concepts, fluid flow equations and fundamental solutions, classical methods for drawdown and build-up analysis, bounded reservoirs, gas well testing, dual-porosity, and hydraulic fractures. Overview of practical methods, some field examples and browsing the commercial software will introduce students to the practice of well testing and pressure transient analysis.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Special Topics on Petroleum Production Systems

Course Code	MPE8067	
Credits	Class hr	Lab hr
3	3	0

The topics of this course are an advanced treatment of modern petroleum production engineering encompassing well deliverability from vertical, horizontal and multilateral / multibranch wells; diagnosis of well performance included elements of well testing and production logging. In this course the function of the production engineering is envisioned in the study to production operations and oil field equipment, multiphase flow, bottom hole pressure prediction, inflow/outflow performance, production systems and backpressure analysis, hydraulic fracturing fluids and equipment; downhole and artificial lift equipment; produced fluids, fluid separation and metering, safety systems, pressure boosting and monitoring, and production data analyses of rate transient analysis (RTA) and pressure transient analysis (PTA) in shale gas. Objectives include understanding the skills to model the unique components of the multiphase production system, and learning advanced techniques for modeling single-well deliverability and multiphase flow in wellbores and pipelines. Special emphasis is given to the components of multiphase production downstream of the sandface, including: slug flow and pigging, flow assurance, multiphase metering, compact separation and multiphase pumping. Transient multiphase modeling will be performed using simulator as well as with simplified methods developed in the class.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Biomass and Bioenergy

Course Code	MPE8071	
Credits	Class hr	Lab hr
3	3	0

Energy is one of the vital inputs to the socio-economic development, and it plays a major role in the development and progress of any nation. Bioenergy derived from renewable resources could be an effective and sustainable alternative, particularly if sourced from microorganisms. Despite the tremendous potential of renewable energy sources, their efficient utilization and implementation is still questionable, and a lot of research is needed before its realization. Therefore, it is necessary to study the basics of biochemistry of the biomass production before we aim for biofuel production. This course deals with fundamental biochemistry related with bioenergy production. This course also deals with various technologies for producing bioenergy such as solid biofuel, gas biofuels (methane and hydrogen) and liquid biofuels (bioethanol and biodiesel) from renewable biomass. This course provide the students an in-depth understanding of the biochemical pathways for the generation of energy molecules such as biohydrogen, bioethanol and biomethane.

**Frequency of offering:** Every Spring

**Prerequisite:** Environmental Engineering

Classification: Major Elective

## Advanced Bioremediation Engineering

Course Code	MPE8072	
Credits	Class hr	Lab hr
3	3	0

The rapid industrial and economic development, human activities have instigated widespread pollution of the natural global environment. Microorganisms and plants in the natural environments play the predominant role in the mitigation of environmental pollutants. Microorganisms are well suited to this task because of large numbers of microbial species that thrive in a variety of environments. Microbes can adapt to changes in environmental or substrate conditions, exhibit high metabolic and growth rates, and are collectively able to catalyze a wide range of metabolic reactions. The purpose of this course is to study bioremediation of inorganic and organic contaminants using a variety of microorganisms and plant species. Different types of contaminants, their transport and fate in the environment will be studied. The course will cover the topics such as physicochemical processes, fundamentals of the microbial and plant systems, remediation methodologies for the removal/degradation of the contaminants, application of bioremediation via microorganisms and plants (phytoremediation).

**Frequency of offering:** Every Spring

**Prerequisite:** General Chemistry

Classification: Research Elective

## **Research Method in Earth Resources and Environmental Engineering**

Course Code	<b>MPE8078</b>	
Credits	Class hr	Lab hr
3	3	0

This course is designed for high- intermediate and advanced ESL university students at the graduate level in a variety of academic disciplines who are in the process of writing their manuscript or thesis. Through reading and writing various of proposals, theses, or dissertations, students will be able to recognize and use the discourse conventions of their field, students will engage in various contextualized writing and language activities that will enable them to match appropriate American English discourse and linguistic forms to specific rhetorical purposes. This course will address such issues as documentation of sources, organization, unity, coherence, emphasis and subordination of ideas, word choice, readability, and audience. By the end of the course, students should be able to translate what they have learned into manuscripts that conform to the expectations of the English- speaking scientific / academic community.

**Frequency of offering:** Every Spring

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Nuclear Engineering**



Classification: Major Elective

## Advanced Nuclear Thermal Hydraulics

Course Code	NUE8061	
Credits	Class hr	Lab hr
3	3	0

This course aims on learning advanced nuclear thermal hydraulics occurring in nuclear power plants in many aspects. Through this subject, students are expected to learn more details about nuclear energy production and its appropriate treatment, effective heat removal techniques in accordance with reactor operating conditions, and management of nuclear thermal-hydraulic systems upon steady and transient states. This subject also covers advanced applications of thermal-hydraulic systems for next generation nuclear reactor systems. This course will cover nuclear energy production and its proper treatment, power cycle and plant thermodynamic analysis, fluid mechanics for nuclear systems, conduction and convective heat transfer in the nuclear systems, and boiling and two-phase heat transfer in the nuclear systems. Relevant topics related to assuring sufficient thermal safety of practical nuclear systems are discussed for the commercial nuclear power plants such as PWR and PWR.

**Frequency of offering:** Every Other Year

**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

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Department of  
**Organic and  
Nano Engineering**



Classification: Major Elective

## Topics of Polymer Engineering

Course Code	ONE6014	
Credits	Class hr	Lab hr
3	3	0

The relationship between polymer structure, properties, and applications is of obvious importance to chemists and engineers working in the polymer industries – plastics, rubber, fibers, coatings, and adhesives. Most technical people in these industries feel a need for greater understanding of these relationships. Most courses and literature on the subject are concerned mainly with the theory of mechanical and thermal properties; while most of the practical knowledge is dispersed throughout the industry in technical bulletins or unpublished form. This course emphasizes thermal, mechanical, electrical, and optoelectronic properties in relation with the structures of polymer and discusses recent research topics. This lecture will help students to understand basic ideas of the polymer's properties and to expect the property of a new polymer.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

## Instrumental Analysis

Course Code	ONE6015	
Credits	Class hr	Lab hr
3	3	0

The importance of instrumental methods in conjunctions with conventional analytical methods is that a modern, well-educated scientist is one who is capable of solving problems with an analytical approach and who can apply modern instrumentation to problems. To be such a scientist, students need to obtain information in diverse areas of science and technology. In addition, students need to understand fundamental principles of instrumental measurements and know about applications of these principles to specific types of chemical measurements, examples of modern instrumentation, and the use of instruments to solve real analytical problem. This lecture focuses on fundamentals and applications of instrumental analysis techniques including ultraviolet-visible and infrared spectroscopies (UV and IR), nuclear magnetic resonance spectroscopy (NMR), mass spectroscopy, and surface characterization by X-ray and UV photoelectron spectroscopy (XPS and UPS), Auger electron spectroscopy (AES), atomic force microscopy (AFM) and scanning tunneling microscopy (STM).

**Frequency of offering:** Every Other Fall

**Prerequisite:** None

Classification: Major Elective

**Soft Materials Engineering**

Course Code	<b>ONE6016</b>	
Credits	Class hr	Lab hr
3	3	0

Soft matter is a class of materials including polymers, colloids, surfactants, liquid crystals, and biomolecules. These materials are very important in our life and technologies. Material is the substance or matter from which something is or can be made, or also items needed for doing or creating something. Soft Matter comprises a variety of states that are perhaps best distinguished by being dominated by energies of order of thermal energies at room temperatures more or less. At these temperatures, quantum aspects are generally unimportant. At this point, understanding on the meaning of soft materials and their physical behavior in molecular level is very important. In this course, fundamental concepts of soft materials will be introduced in this course. This course mainly covers a solid concept of soft materials. In depth, characterization, properties and applications of soft materials will be discussed. The students will be able to apply the covered course materials in their respective areas of research.

**Frequency of offering:** Every Other Fall**Prerequisite:** Advanced Materials Science

Classification: Major Elective

**Advanced Materials Science**

Course Code	<b>ONE6018</b>	
Credits	Class hr	Lab hr
3	3	0

Every moment of human's life is intimately related to materials and is significantly influenced by materials. Development of materials has lead huge progress in transportation, housing, health, clothing, communications, and food production. The development of many technologies making our lives much better has been closely correlated with the information about suitable materials. The understanding of a material type and its properties enables us to make a breakthrough of a technology. At this point, the fundamental concepts of materials science and engineering will be introduced in this course. This course covers a solid concept of organic/inorganic materials in depth and their design, characterization, properties and applications will be discussed. The relation of materials type and their properties including electrical, thermal, magnetic, and optical properties will be mainly discussed. The students will be able to apply the covered course materials in their respective areas of research.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

## Hybrid Functional Carbon Nano Materials

Course Code	ONE6020	
Credits	Class hr	Lab hr
3	3	0

Due to the outstanding materials properties of carbon, it is extensively used in one form or another in a variety of systems. As a new material's era, we are encountering carbon nanomaterials' era. A variety of carbon materials, such as carbon nanotubes, activated carbons, carbon black, carbon fibers, artificial carbons, graphene, have been widely investigated and applied to various applications. In many of applications, carbon is exposed to a wide range conditions. At this point, the understanding of properties of carbon nanomaterials enables us to make a breakthrough of a technology. Fundamental concepts of carbon nanomaterials will be introduced in this course. This course covers a solid concept of synthesis and preparation of carbon nanomaterials, strategies for organic/inorganic hybrid materials in depth. The characterization, properties and applications of carbon nanomaterials will be discussed. The relation of materials type and their properties including electrical, thermal, and optical properties will be mainly discussed. The students will be able to apply the covered course materials in their respective areas of research.

**Frequency of offering:** Every Other Fall

**Prerequisite:** Advanced Materials Science

Classification: Major Elective

## Topics in Industrial Statistics

Course Code	ONE9039	
Credits	Class hr	Lab hr
3	3	0

In this course we will study the Statistics that all engineering students in MS or Ph.D degree must be aware of. Note that although the Statistics is important to all graduate students in Economics, Sociology, Medical Science, Pharmacy, and Engineering, it is utmost vital to engineering students who need to manage and analyze great amount of data. This class explores general fundamentals of the Statistics as well as some applications such as regression analysis and experimental designs. There will be an emphasis on theory of probability and statistics, random variables, inference, and hypothesis testing that is essential for subjects/matters such as collecting data, analysis, examination, practice, etc., that occur in industries. By exploring basic theories of the Probability and Statistics and applications systematically, this course seeks to increase students' knowledge and advance ability in thinking and treating every data that is related to engineering studies.

**Frequency of offering:** Every Other Spring

**Prerequisite:** None

Classification: Major Elective

**Polymer Optoelectronic Nano Materials**

Course Code	ONE9046	
Credits	Class hr	Lab hr
3	3	0

In the earliest applications polymers were restricted largely to a role in which they were utilized for their insulating properties. Examples here include cable insulation, valve bases, capacitor dielectrics and equipment housing/casing. With the rapid commercialization of semi-conductor technology during the 1950s, the number of potential uses for polymer materials increased significantly. The principal reason why polymers find wide application in electronics and optoelectronics is that they are good dielectric materials with readily controllable properties. More recently, many polymers have been developed that have additional intrinsic properties that make them of special interest in advanced electronics and optoelectronics applications. This lecture focuses on the fundamentals of opto-electronic organic molecules and polymers which have found applications in organic light emitting diodes (OLED), organic thin film transistors (OTFT), and organic solar cells. The operating mechanism of the devices and the latest techniques in OLED, OTFT and organic solar cell will be discussed in the class.

**Frequency of offering:** Every Other Spring**Prerequisite:** None

Classification: Major Elective

**Advanced Electronic Materials Nano Processing**

Course Code	ONE9047	
Credits	Class hr	Lab hr
3	3	0

Progress in nanotechnology depends upon the capability to fabricate nanostructures in a variety of materials with accuracy in the nanometer scale and sometimes in the atomic scale. Depending on application, there are varying degrees of strong specifications, which have to be met in industrially relevant processes due to manufacturability and costs considerations as, for example, in the electronics industry. However, it appears that less demanding conditions are needed for developments in optics, sensors and biological applications. In order for progress to be made, enabling nanofabrication techniques as tools for experiments to understand the underlying science and engineering in the nanometer scale, easily accessible and flexible nanofabrication approaches are required. This lecture focuses on the introduction of conventional and unconventional lithographic methods including photo lithography, e-beam lithography, X-ray lithography, ion-beam lithography, soft lithography, nano imprint lithography, dip-pen lithography, and block copolymer lithography. This lecture also emphasizes their applications in electronic devices.

**Frequency of offering:** Every Other Fall**Prerequisite:** None

H A N Y A N G   U N I V E R S I T Y

Department of  
**Urban Planning  
and Engineering**



Classification: Major Elective

## Seminar in Urban Planning

Course Code URE7029		
Credits	Class hr	Lab hr
3	3	0

Cities are faced with growing social and economic disparities, which can in turn negatively affect social support networks, decrease interpersonal trust and trust in public institutions, and contribute in the future to social and political conflicts. These negative trends can erode social cohesion in cities and consequently reduce their capacity to effectively cope with future social, economic and environmental risks. Urban planning is one of the key instruments that can help cities restore their social and territorial cohesion, which is an important step towards long-term sustainable urban development. This seminar will help students to understand the relation between urban planning and sustainable urban development by focusing on successful urban regeneration practices in East Asia and Europe and their social consequences on everyday life in cities. Particular attention will be placed on urban planning in Seoul. Students will conduct their own fieldwork to better understand evolving urban regeneration in Seoul.

**Frequency of offering:** Every Other Fall

**Prerequisite:** None