# Asian Network for Education on Nuclear Technology

## Information Request about Curricula
### on Nuclear Technology and Non-Power Peaceful Applications of Atomic Energy in Asian Countries

## 1. General information about Data provider:

1.1. **Full Name and Your Title:** **Kyong-Won Han/Director of Nuclear Training Center, KAERI**

1.2. **Address:** **P.O. Box 105, Yuseong, Daejeon 305-600 (kwhan@kaeri.re.kr)**

1.3. **Country:** **Republic of Korea**

## 2. Information about Institution realizing educational program

2.1. **Name of the Institution :** **KAIST(Korean Advanced Institute of Science and Technology)**

| II. Information on courses of the curricula | | | | | |
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| No. | Title of Course | Number of Credits | Objectives of the Course | Provided for students of X year? | Remarks |

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| Course No.1 | Nuclear and Quantum World | 3 | This course introduces the basic concepts of quantum mechanics and quantum phenomena through historical reviews and non-mathematical approach, and discusses the major fields of nuclear and quantum engineering such as nuclear fission and fusion, quantum beam science, medical imaging, quantum imaging, quantum computer and etc. In addition to the technical aspects, the course discusses the impacts of energy development on international politics and environmental issues, and the role of quantum technology in the 21st century. | undergraduate | |
| Course No.2 | Fundamentals of Nuclear and Quantum Science | 3 | This course introduces the elements of quantum mechanics and nuclear physics, which are the basis of quantum engineering, radiation applications, and nuclear technology. The main contents include particle and wave duality, wave function, schrodinger equation, operators and eigenvalue equations, superposition principles, uncertainty principle, Hilbert space, quantized energy level and spin 1/2 particle two-level quantum system. Understanding the basic quantum mechanics, we discuss the atomic and nuclear structures and radiation interactions with matter. | “ | |

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| Course No.3 | Fundamentals of Nuclear Engineering I | 3 | This course is designed to cover the basic engineering principles underlying the nuclear power plant design and operation. Major subjects are : ① fundamentals of nuclear reactions and cross sections, ② introduction to nuclear power reactors, ③ nuclear fuel cycles and radioactive waste disposal, ④ fundamentals of nuclear reactor theory, ⑤ heat transfer of nuclear reactors. | " | |
| Course No.4 | Fundamentals of Nuclear Engineering II | 3 | For nuclear power plant design and operation, introductory comments on nuclear materials, radiation effects, corrosion damage, and nuclear fuels are included. Introductory remarks on radiations, simple calculation on gamma ray and neutron shielding. Radiation effects, units and calculational methods are described basically. Various sources of radiation and standards of various radiation effects are explained. Also quantitative effects of radiation on human and corresponding radiation effects are calculated and analyzed. Reactor licensing, safety principles and dispersions of effluents from nuclear facilities are discussed. Finally reactor incidents, accidents and risk analysis will be briefly introduced. | " | |

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| Course No.5 | Introduction to Radiomedical Physics | 3 | The basic radiation physics for medical applications and the basic concepts in radiology, nuclear medicine and radiation therapy are introduced. For the radiology, the X-ray CT, the magnetic resonance imaging(MRI), and the ultrasonic imaging techniques are discussed, and for the nuclear medicine, the positron emission tomography(PET) and the single photon emission computed tomography(SPECT) are discussed. The Fourier transformation and its applications are briefly introduced to help concrete understanding of the basic imaging principles. To help students to read some actual medical images, the human anatomy and physiology are briefly introduced as well. | “ | |
| Course No.6 | Energy and Environment | 3 | Comparative assessment of resources and technologies for renewable energy, fossil energy, nuclear energy, and future energy. Evaluation of abatement technologies and strategies to reduce environmental impacts arising from the various energy uses in order for the food harmonization of energy supply and environmental preservation so as to sustain socioeconomic development | “ | |

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| Course No. 7 | Nuclear Reactor Theory and Simulation | 3 | This course is designed to introduce fundamental reactor analysis related with neutron reaction, nuclear fission and chain reaction system. Major subjects are : neutron slowing down in infinite medium, neutron diffusion theory, approximation of few neutron energy group and criticality calculation, heterogeneous reactor, dynamics and reactivity feedback effects, and projects running computer code systems of reactor analysis (neutron moderation, two-group neutron diffusion equation, depletion calculation, dynamics, etc). | “ | |
| Course No. 8 | Design and Implementation of Nuclear Systems | 1 | In this course, a lot of design constraints such as design basis, functions and technical specifications that govern the whole phases of design processes will be lectured to point out drawbacks and enhancement directions of designed systems. In addition, through implementations of small-scale mockups, a chance for enhancement directions that are suggested by students would be provided. | “ | |
| Course No. 9 | Nuclear Chemistry and Experiments | 3 | Various nuclear reactions and chemical characteristics applied to nuclear engineering and technology will be handled in all it's aspect. Radioactive decay, nuclear reaction, interactions between various radiations and materials, characteristics and generations of various radiations, production, utilization and characteristics of radionuclides, radioactive activation analysis and method, uses of radioactive tracers, radiochemistry, isotope separation and applications will be dealt with in the course. Then each chapter will be covered with related basic experiments. | “ | |

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| Course No. 10 | Radiation Health Physics and Experiments | 3 | Course covers the unit of radioactivity and the dose, the effect of ionizing radiation in matter and biological objects. It also deals with the internal and external dosimetry and risk, ICRP recommendations and the regulations related to radiation protection, and the management of radioactive materials and the radiological emergency planning. | “ | |
| Course No.11 | Nuclear Energy Economics and Management | 3 | This course is intended to provide undergraduate students with the principles of engineering economics and its interrelationship with technology management and policy making as applied to nuclear power industry. The emphasis will be placed on quantitative economic analysis for licensing, construction, operation, maintenance, and regulation of nuclear power plants. | “ | |
| Course No.12 | System Engineering of Nuclear Power Plants and Experiments | 3 | Unified treatment of the design concept and overall description of components and system control in nuclear power plants. Discussion of engineering and operational valves, BOP, CVCS, and Engineered Safety Features. Emphasis on the basic concepts of thermodynamics associated with nuclear power plants. Performance of experiments of each component and simulation of the system through a micro-simulator. | “ | |

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| Course No.13 | Nuclear and Quantum Engineering Design Project | 2 | This course provides students by group with performing the actual applications by uniting the reactor physics, reactor control, heat transfer, safety analysis, materials, quantum engineering. This course makes the opportunity to integrate all acquired knowledge from other courses and to apply it to practical problems in the interesting design field. | “ | |
| Course No.14 | Monte Carlo Methods and Applications | 3 | This course deals with fundamentals of the Monte Carlo methods: (1) random variables and random number generation, (2) sampling procedures, (3) analog Monte Carlo, (4) non-analog Monte Carlo and variance reduction techniques, and then applies the methods to a selection of representative benchmark problems from several application areas: (5) radiation particle (neutron, -ray, and charged particles such as electron and alpha particle) transport problems, (6) bio/nuclear medicine systems design, (7) multiple integrals and integral equations, (8) molecular dynamics and quantum Monte Carlo simulation, (9) socio/economics prediction models, and (10) optimization problems. | “ | |

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| Course No.15 | Nuclear Thermal Hydraulics and Experiments | 3 | This course deals with the basic theory and experimental methods related to nuclear thermal-hydraulics. Major subjects are : ① fluid mechanics and heat transfer in single and two-phase flows, ② heat exchanger design, ③ core thermal design, ④ measurements of various thermo-physical properties and important thermal-hydraulic variables used in the nuclear thermal-hydraulics. | “ | |
| Course No.16 | Nuclear and Quantum I&C and Experiments | 3 | This course is designed to provide high level undergraduate and graduate students in nuclear and quantum engineering with the basic electric and electronic knowledge such as electronic circuit, power electrics, power transmission and introductory instrumentation and control by theoretic analysis and experiments. | “ | |
| Course No.17 | Information Engineering for Nuclear and Quantum Applications and Experiments | 3 | This course is designed to provide high level undergraduate and graduate students in nuclear and quantum engineering with the basic knowledge on digital hardware, software, and cognitive engineering and with the capability of analysis and design of integrated man machine systems. | “ | |
| Course No.18 | Environmental Engineering of Nuclear Power | 3 | Environmental effects of nuclear power, and it's environmental preservation and management, effluent and waste heat management of nuclear power and nuclear fuel cycle facilities, environmental dispersion of radioactive effluents, power plant and radioactive disposal siting and technical assessment of various technology will be covered. | “ | |

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| Course No.19 | Nuclear and Quantum Materials and Experiments | 2 | Basic concepts and applications of nuclear materials are introduced, while laboratory practices are designed for experiencing property tests of the lectured materials. Lectures include the essential knowledge of materials science as well as the effects of radiation and environments on material properties. The experiments are concerned with mechanical test and data analysis phase transformation, observation by optical and electron microscopes, corrosion tests, and irradiation effects. | “ | |
| Course No.20 | Introduction to fusion Reactor Systems | 3 | Course discusses the engineering feasibility and technical factors of fusion reactor. Plasma issue, fuel cycle, fusion reaction kinetics, balance of energy and particles, material issues related the first wall, and the tritium recovery, energy extraction and heating methods will be covered. | “ | |
| Course No.21 | Radiation Detection Experiments | 2 | Course covers the basic theory of and experiments on counting and spectroscopy of ionizing radiation, such as alpha, beta, gamma, x-ray and neutrons. Also the principles of gas-filled, semiconductor and scintillation detectors together with the pulse electronics, x-ray radiography and basic nuclear medical instrumentation are discussed. | “ | |

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| Course. No.22 | Radiation Biology | 3 | This course deals with the irradiation effects on cells and the bio-organic systems. It covers from the physical and chemical effects of radiation on the living tissue to the non-stochastic effect of human body. Also the applications of radiation biology, such as radiation therapy, sterilization and improvement of breed are discussed. | “ | |
| Course No. 23 | Reactor Experiments | 1 | Course covers the various experiments using the experimental nuclear reactor such as production of radioisotopes, neutron radiography, burn-up measurement of spent fuel by gamma spectroscopy, and neutron activation analysis et al1. | “ | |
| Course. No.24 | Special Topics in Nuclear and Quantum Engineering 1 | 2 | Course covers the special field of nuclear engineering which is not covered by the given courses. The content can be variable and will be chosen by the instructor. | “ | |
| Course. No.25 | Special Topics in Nuclear and Quantum Engineering II | 3 | Course covers the special field of nuclear engineering which is not covered by the given courses. The content can be variable and will be chosen by the instructor. | “ | |
| Course No.26 | Seminar | 1 | Seminar is given by the staff of the department or invited guest speaker on topics of recent interest in the overall field of nuclear engineering, including the design and operation of nuclear reactors, reactor kinetics, heat transfer, energy conversion, radiation shielding, nuclear fuel cycle and management, nuclear materials and safety, and radiation technology etc. | “ | |

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| Course No.27 | Venture Internship | 0 | This course is to provide junior or senior undergraduate students with the opportunity to experience and practice at the venture companies what they learned from the regular courses at the university. | “ | |
| Course No.28 | Nuclear Reactor Kinetics | 3 | This course is designed to cover the dynamics of nuclear systems. Major subjects are : ① delayed neutrons and inhour equations, ② response to constant, step, and time-dependent reactivates, ③ mechanisms of feedbacks - linear and nonlinear feedback models, ④ transfer functions, ⑤ linear and nonlinear stability criteria, ⑥ Lyapunov method, and ⑦ limit cycles and nonlinear oscillations. | graduate | |
| Course No. 29 | Nuclear Reactor Analysis and Design | 3 | This course is designed to cover the nuclear reactor analysis and design, introduction of neutron transport equation, approximation of diffusion theory, solution of few-group and multi-group neutron diffusion equation, calculation of energy distribution of fast and thermal neutrons, and homogenization to heterogeneous reactors. It also include recent methods (ex. nodal method) to predict the spatial and temporal distribution of neutrons, This course includes several projects running design computer code systems under realistic reactor design situation. | “ | |

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| Course No. 30 | Neutron and Quantum Particle Transport Theory | 3 | This course is designed to cover the particle transport solution theory, numerical algorithms, and computational methods for continuous, one-group, multi-group neutron and radiation transport phenomena. Major subjects are : singular eigenfunction expansion, Green's function, spherical harmonics, discrete ordinates, integral transport, even-parity transport, method of characteristics, Boltzmann-Fokker-Planck transport methods for various quantum particle(neutrons, photons, electrons, positrons, protons, etc) transport phenomena, applied to the design of various nuclear reactors, radiation shielding facilities, analysis of radiation and energy deposition profiles in systems such as nuclear fusion reactor, accelerator, nuclear bio-medical equipment, semiconductor electronics system, and nuclear imaging problems such as nuclear prospecting, nuclear assay, computed tomography. | “ | |
| Course No.31 | Nuclear Reactor Engineering | 3 | The primary objective of this course is to cover the engineering analysis in the design of nuclear fission power reactors. Major subjects included and : ① a brief description of the various types of nuclear power plants currently in use or under serious consideration, ② thermal-hydraulic analysis of nuclear reactors, ③ analysis of operational and accident transient sequences, ④ nuclear and thermal-hydraulic transient, and ⑤ engineering aspects of nuclear reactor safety. | “ | |

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| Course No. 32 | Nuclear Thermal-Hydraulics | 3 | This course is meant to cover advanced topics of the nuclear thermal-hydraulic design and analysis of the core of a nuclear reactor along with the related current reactor thermal-hydraulic research topics. Major subjects included are : ① reactor thermal hydraulic design problems, ② transient analysis of a single and multiple heated channels, ③ thermal analysis of the spent fuel storage canister, ④ analysis of hypothetical severe reactor accidents, ⑤ source term uncertainty analysis, ⑥ hypothetical core disruptive accident of an LMFBR, and ⑦ current research topics of the nuclear thermal-hydraulics. | “ | |
| Course No. 33 | Nuclear Power Plant Design Project | 3 | The objective of this course is to accumulate the composite design experiences of the core and other equipments using the principles of nuclear engineering. Unique design of reactor core satisfying the parameters of the particular reactor type, the output of power and the limit temperature, etc., the size of core and the size, the number, the interval and the operating temperature, etc. of fuel rods must be determined by computational codes. It also includes an estimate of the cost price for a reactor system containing heat exchangers, steam generators, condensers, turbines, etc. | “ | |

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| Course No. 34 | Nuclear Reactor Safety Ⅰ | 3 | This course deals with the safety objectives, the safety features, the safety analysis methods and the diagnostic techniques for a nuclear power plant. The probabilistic safety assessment is emphasized, which it includes the deterministic analysis for transient state and design basis accident, and the system reliability, the severe accident generation rate and phenomena. It also deals with TMI accident, Chernobyl accident and other severe reactor accidents as practical examples. | “ | |
| Course No. 35 | Simulation of Nuclear and Quantum System | 3 | his course provides students with understanding of numerical analysis, artificial intelligence and simulation methodologies which can be applied in nuclear and quantum engineering. To solve the partial differential equations, finite difference method, finite element method, Monte Carlo method and so on are discussed. In the artificial intelligence part, the course covers expert system, neural network, fuzzy theory, and other artificial intelligence language. Students can understand about uncertainty problem and sensitivity study in computer codes. | “ | |
| Course No. 36 | Structural Mechanics in Nuclear Power Reactors | 3 | Course deals with the functional objectives of the structural components of nuclear reactor system, operational parameters and nuclear conditions, and the required specifications for the mechanical and structural design of nuclear reactors. Components design criteria based on the mechanics and material transport simulation will be discussed. | “ | |

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| Course No. 37 | Quantum and Micro Energy Transport | 3 | This course provides students with understanding of quantum and micro energy transport phenomena. This course covers the concept of energy carriers - phonon, electron and photon, and analytical methods based on molecular dynamics simulation. This course will make discussions on applied areas such as thermoelectric power generation and cooling, heat conduction and phase change in thin film, and micro measurement techniques. | “ | |
| Course No. 38 | Nuclear and Quantum Instrumentation Systems | 3 | This course is designed to provide graduate and high level undergraduate students who want to understand and to have skills on analysis and design of nuclear power plant and quantum instrumentation systems with the knowledge on instrumentation and sensor theory, various process instrumentation techniques as well as many nuclear power plant instrumentation systems and quantum engineering instrumentation systems. | “ | |
| Course No. 39 | Nuclear and Quantum Control Systems | 3 | This course is designed to provide graduate and high level undergraduate students with control theories such as control action, stability analysis, state-space analysis and with the detailed analysis skills of nuclear power plant control subsystems such as reactor control system, feedwater control system, pressurized control system, and quantum engineering control systems. | “ | |

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| Course No. 40 | Compact Nuclear Simulator Operation Experiment | 1 | This course is designed to provide high level undergraduate and graduate students with the opportunity to operate nuclear power plants at normal, abnormal, and emergency conditions with compact nuclear simulators. | “ | |
| Course No. 41 | Nuclear Chemical Engineering | 3 | Overall chemical engineering process technologies and principle applicable to nuclear engineering are covered and described. Technology applied and newly developed for nuclear fuel cycle will be discussed in detail. Radioactivity and decay chain analysis method, technology or process applied to front-end fuel cycle, characteristics and analysis of nuclear spent fuels, fission products, and actinide, fundamentals of nuclear water technology and isotope separation methods are described in detail. | “ | |

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| Course No. 42 | Radioactive Waste Management | 3 | This course is designed to provide the students about the technology of the general management of the radioactive waste generated during the operation of nuclear power plant and nuclear fuel cycle facility including the treatment and disposal of the wastes. Background information on the sources of the gaseous, liquid and solid radioactive waste, and process and treatment facilities, solidification and volume reduction technology, packaging and transportation, storage methods of the wastes and spent nuclear fuel, design, safety and construction of the waste repositories, migration of the radionuclide at the subsurface, environmental monitoring and protection, repository safety assesment, decontamination and decommissioning, and the management of spent nuclear fuel will be covered. | “ | |
| Course No. 43 | Nuclear Materials | 3 | Nuclear materials are introduced with an emphasis on structural integrity on the basis of materials science. Effects of microstructure and dislocation substructure on mechanical properties, deformation and fatigue properties in various temperatures and environments. Fracture mechanical analysis of crack propagation, stress corrosion cracking, irradiation effects, and recent developments of nuclear materials are included in view of theory and applications. | “ | |

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| Course No. 44 | Advanced Radiation Detection | 3 | Principles of radiation detection and signal processing, applications of radiation and radioisotopes to industrial and medical area will be covered. Also data acquisition and image processing for x-ray computed tomography, single photon emission computed tomography, and positron emission tomography will be discussed. | “ | |
| Course No. 45 | Radiation Protection and Dosimetry | 3 | Course covers radiation sources, interaction with matter, radiation detection methods, biological effects, methodology for reduction of radiation exposure to men and micro- and macro-radiation dosimetry for practical and theoretical problems. | “ | |
| Course No. 46 | NMR Engineering | 3 | This course introduces the basic theory of nuclear magnetic resonance (NMR) phenomena, NMR imaging techniques, NMR spectroscopy techniques and related equipments. In addition to the basic principles of NMR techniques, some examples of NMR applications in biomedical research, nanoporous materials and NMR quantum computations are discussed and some basic NMR experiments related to lectures are performed. | “ | |

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| Course No. 47 | Neutron Optics | 3 | This course introduces the theory of neutron optical phenomena and the theory of neutron scattering for condensed matter research. The contents include the elements of quantum mechanics, the fundamental properties of neutron, neutron nuclear scattering and magnetic scattering, a brief introduction to neutron optical device and neutron scattering instruments. A few practical examples of neutron scattering experiments of nano-and magnetic materials are also discussed. | “ | |
| Course No. 48 | Nuclear Energy Policy | 3 | Historical development and utilization of Nuclear Energy are reviewed from the dawn of atomic age. This important alternative energy technology is evaluated comparatively in terms of technoeconomic, sociolpolitical and environmental aspects of nuclear energy uses. The nuclear energy utilization programs of major countries, regional or global basis are assessed for the characterization of different nuclear energy policy. In view of the established international nonproliferation regime and International Atomic Energy Agency(IAEA), the prospect of Nuclear Energy Policy Alternatives should be analysed in conformity with changing policy issues. | “ | |

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| Course No. 49 | Nuclear Fusion Engineering | 3 | Course deals with the engineering and the design of fusion reactor system. Fusion reaction physics, analysis of fusion reactor, magnetic confinement and inertia confinement, supply of plasma and heating, adiabatic compression and ignition of plasma, economics and environmental effect of fusion reactors will be discussed. Other necessary engineering issues and design examples for fusion technology will be discussed too. | “ | |
| Course No. 50 | Applied Plasma Engineering | 3 | Based on the fundamental understandings of low temperature plasmas, production methods and characteristics of various plasma sources such as gaseous discharges will be studied. Also various examples of industrial applications will be discussed | “ | |
| Course No. 51 | Special Topics in Nuclear and Quantum Engineering I | 3 | Course covers the special field of nuclear and quantum engineering which is not covered by the given courses. The content can be variable and will be chosen by the instructor. | “ | |
| Course No. 52 | Special Topics in Nuclear and Quantum Engineering II | 2 | Course covers the special field of nuclear and quantum engineering which is not covered by the given courses. The content can be variable and will be chosen by the instructor. | “ | |

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| Course No.53 | Nuclear Thermal-Hydraulics Ⅱ | 3 | This course is meant to cover advanced topics of the nuclear thermal-hydraulic design and analysis of the core of a nuclear reactor along with the related current reactor thermal-hydraulic research topics. Major subjects included are : ① reactor thermal hydraulic design problems, ② transient analysis of a single and multiple heated channels, ③ thermal analysis of the spent fuel storage canister, ④ analysis of hypothetical severe reactor accidents, ⑤ source term uncertainty analysis, ⑥ hypothetical core disruptive accident of an LMFBR, and ⑦ current research topics of the nuclear thermal-hydraulics. | “ | |
| Course No.54 | Nuclear Reactor Safety Ⅱ | 3 | In reliability, risk analysis and reactor safety, the problems of higher degree are emphasized. In particular, important safety problems of reactor are selected and reviewed. It also includes the case-studies with participating students discussing | | |
| Course No.55 | Nuclear Fuel and Core Design | 3 | Provision of basic theory and practical applications of thermal-hydraulic, mechanical, and uncertainty analysis to fuel and core design. Discussion of methodology on how these parts are coordinated and integrated to yield economical and safe fuel and core design | | |

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| Course No.56 | Numerical Methods in Reactor Engineering Analysis | 3 | This course deals with the numerical methods for analyzing the problems of nuclear reactor engineering. it is argued for finite difference method and finite element method in order to find solutions of heat transfer, fluid dynamics, component structure design and system transient analysis | | |
| Course No.57 | Nuclear and Quantum Instrumentation and Control Design | 3 | This course is designed to provide graduate students who want to understand and get skills for designing nuclear and quantum I&C systems with detailed analysis skills of subsystems, system integration methods, and pertinent theory and technology<br>. | | |
| Course No.58 | Radiation Effects on Reactor Materials | 3 | Characterization of the different radiation sources, interaction with reactor materials, and resulting radiation damage are analyzed in terms of metal crystalline defects and physical properties of reactor materials. Radiation damage induced core material property change, water or liquid metal side corrosion, diffusion and reaction of fission products, structural stability of metal or nonmetallic materials, radiation hardening or embitterment and swelling are studied and analyzed in terms of lattice defect interaction with energetic neutron | | |

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| Course No.59 | Nuclear Reactor Fuel Elements | 3 | Nuclear fuel and cladding material behavior in nuclear reactor cores are introduced in terms of swelling, fission gas release, and creep. The irradiation and temperature effects are treated in view of theory and experiment, Nuclear fuel design, fabrication, performance assessment models, reliability analysis, and recent trends of nuclear core materials are explained. | | |
| Course No.60 | Special Topics in Nuclear Energy Policy | 3 | Course deals with the evaluation of the modern nuclear energy policy program and the development of analysis methodology for solving various related issues. Also the cost-benefit, risk-benefit, Del-Phi, and the socio-political factor analysis will be discussed in order to be used as the input of the decision making for the new nuclear policy. | | |
| Course No.61 | Special Topics in Nuclear Safety Analysis | 2 | Course covers the special field of nuclear and quantum engineering which is not covered by the given courses. The content can be variable and will be chosen by the instructor | | |

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| Course No.62 | Special Topics in Probabilistic Risk Assessment | 2 | This course deals with the methodologies and applications of PRA, and computer codes. Among the methodologies, there are probabilistic analysis and accident result analysis. The former includes data processing, fault tree, human error, common mode error and uncertainty analysis. The latter includes containment vessel state, core exposure and melting, pressure vessel melting penetration, core-concrete reaction, atmosphere source terms, radioactive nuclide dissipation and public result. This also includes various applications as the decision-making. | | |
| Course No.63 | Special Topics in Information Engineering for Nuclear and Quantum Applications | 3 | This course is designed to let the graduate students understand the state-of-the-art research activities in information engineering for nuclear and quantum applications and have them participate in the research through individual projects | | |

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| Course No.64 | Special Topics in Nuclear Chemical Engineering | 3 | Application of nuclear chemical engineering related to the overall facilities of nuclear power and fuel cycle will be introduced and discussed. The advanced topics of characteristics and effects of various radioactive materials, properties and characteristics of fission products, nuclear and radiochemistry, various nuclear fuel cycle alternatives, isotope separation, storage and reprocessing of spent nuclear fuel, treatment and disposal of radioactive wastes, environmental impacts and environmental friendly nuclear power assessment will be covered and carefully reviewed. | | |

**2.2 Name of the Institution: Hanyang University**

| II. Information on courses of the curricula | | | | | |
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| No. | Title of Course | Number of Credits | Objectives of the Course | Provided for students of X year? | Remarks |
| Course No.1 | Overview of Nuclear Engineering | 3 | This course discuss the history of nuclear energy, fundamentals of nuclear fission/fusion reactions, nuclear weapons, nuclear reactor and fuel cycles, nuclear safety and a variety of radiological applications. Current topics such as public acceptance and future of nuclear engineering are offered during the next two years. | 2 | |
| Course No.2 | Applied Nuclear Physics | 3 | In order to understand the basics of modern physics, atomic physics nuclear structure and nuclear reactions, this course covers applied nuclear physics. | 2 | |
| Course No.3 | Interaction of Radiation with Matter | 3 | In this course, students discuss the nature of radioactivity and decay rule, radiation sources, types and characteristic of radiation, interaction of heavy charged particles, neutrons and photons with matter, kinematics and cross sections of interactions. The concept of radiation dose resulting from energy transfer through interactions is also covered | 2 | |

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| Course No.4 | Nuclear Reactor Engineering | 3 | This course discusses basic nuclear reactor principles including the interaction of neutrons with matters, nuclear reaction and reaction cross sections, the structure of nuclear reactors, neutron diffusion equitation, nuclear reactor reactors criticality, multiplication factors, nuclear reactor kinetics equations for transient reactors reactivity control methods and others. | 2 | |
| Course No.5 | Quantum Energy Engineering Laboratory | 1 | In order to answer the basic engineering questions, the following are covered: data acquisition, fitting and err analysis; Design and construction of simple diagnostics, measurement of field intensity and plasma and charged particles and optics experiments. | 2 | |
| Course No.6 | Radiation Detection and Management | 3 | In this course, operating principles and characteristics of variety of radiation detectors including gas-filled detectors, scinitillator, semiconductor and solid state track detectors. Thermoluminescenece dosimeters, and neutron detectors are discussed. Discussion on counter electronics, pulse height analysis counting statistics and background reduction are followed. | 2 | |
| Course No.7 | Applied Thermodynamics | 3 | This course consists of three parts. The first part is to introduce basic concepts: energy entropy, free energy and the laws of engineering thermodynamics. In the second part, power plant cycles with an emphasis on the Rankine cycle are thoroughly reviewed. The third part covers phase equilibrium and its diagram, reactions and gas phase reactions involving pure condensed phases and a gaseous phase | 3 | |

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| Course No. 8 | Radiation Engineering & Technologies | 3 | This course discussed principles and techniques applied to industrial gauges, tracers, radiation analysis, activation analysis, radiation processing, and radiography. Applications in life science and environmental protection are also included. | 3 | |
| Course No. 9 | Heat & Mass Transfer | 3 | This course is an introduction to the conservations of mass/momentum/energy and the basic mechanisms of conduction/convection/radiation heat transfer. This course is aimed towards learning fundamental knowledge on heat and mass transfer. | 3 | |
| Course No.10 | Nuclear Methods in Medical Science | 3 | In this course, discussions on the overall utilities of radiation in contemporary medicine are held. The course includes diagnostic x-ray, microtrons and cyclotrons as therapy beam sources or radioisotope generators, varieties of nuclear pharmaceuticals, radio-immuno techniques, in vivo/in vitro analysis, CT and SPECT/PET systems. | 3 | |
| Course No.11 | Reliability Analysis | 3 | In this course, parametric and non- parametric methods, life testing and Bayesain estimations for evaluating failure reliability of equipment are discussed. Also system reliability or risk analysis, the reliability block diagram method, failure mode and effects analysis, fault tree, event tree. Markovian method, common cause analysis and importance measures are discussed. | 3 | |

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| Course No.12 | Radiation Shielding Design | 3 | This course introduces the concept and analysis technology of radiation attenuation, absorption and scattering within shielding material and teaches the calculation of radiation flux distribution, technology of optimum shielding design. The monte Calro calculation method, etc. Also, it includes an understanding and application of computational codes for shielding analysis. Object for consideration are that all nuclear facilities have a need for protection in regards to the design core outer assembly, analysis of high-level radiation fields within the plant treatment of high-level radioactive materials, radiation field analysis in storage facilities, the design of radioactive material transport containers, shielding and the design of high energy accelerators and fusion reactors among others. | 3 | |
| Course No.13 | Applied Material Science | 3 | This course deals with electric currents, magnetic fields; biot-Savarts law of magnetization; Faraday's law of introduction, time-varying fields; Maxwells equations and electromagnetic waves. | 3 | |
| Course No.14 | Nuclear Reactor Theory | 3 | This course focus on the principles of compound nuclear reactions, neutron chain reaction, the derivations and applications of one-speed and multi-group neutron diffusion equations, analysis of critical reactors, numerical solutions of the neutron diffusion equation, nuclear reactor kinetics for understanding relationships between reactivity and power and more. | 3 | |

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| Course No. 15 | Radiation Doses and Biological Effects | 3 | In this course, concepts and quantities involving radiation exposure are discussed in depth, focusing on the equivalent dose, committed dose, dose equivalent and operational quantities defined by ICRU. Anthropomorphic phantom for dosimetry are discussed. Also introduction of DNA, lesions and repair mechanisms, deterministic effects, stochastic effects and the resulting risks of radiation exposure are covered. | 3 | |
| Course No.16 | Probabilistic Risk Assessment | 3 | In this course, fundamental concepts and techniques of level 1, 2 and 3 probabilistic risk analysis for complex systems, initial incident and responses of plant and operators, extensions of accident effects, safety functions and unavailability analysis of safety systems, analysis of human errs, quantification of accident sequence etc. will be discussed. | 3 | |
| Course No.17 | Nuclear Engineering Laboratory | 3 | In this course, precision measurement of mass and temperature, material analysis, material testing and radiation counting and measurements using GM counters scintillation counters, SCA and MCA, survey techniques for radiation and contamination levels are practiced. | 1 | |
| Course No.18 | Nuclear Reactor Thermohydraulics | 3 | This course covers heat generation and distribution in the reactor core mechanism of heat removal by coolant flow, critical thermal factor and the related theory for reactor design and boiling and two phase flow phenomena. Also, basic fundamental s for heat transfer in reactor core and reactor thermal design are covered. | 3 | |

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| Course No.19 | Engineering Electromagnetics | 3 | Electrostatic and electro-magnetics are covered as the bases of experimental devices in fission and fusion technology along with vector analysis, Coulomb's law, Gauss's law, Electric and Magnetic properties of matter, Electric Circuits, Faraday's law and Ampere's law. | 3 | |
| Course No. 20 | Nuclear Reactor Materials | 3 | In this course, major issues in nuclear reactor materials science are reviewed. Oxidization of zirconium alloys, nuclear fuel swelling, fission gas release, irradiation creep, radiation damage theories and issues in thermonuclear fusion reactors are discussed. | 4 | |
| Course No. 21 | Nuclear Energy Policy | 3 | In this course, the status of domestic nuclear energy programs, the national policy to develop advanced nuclear technology, nuclear safety, the nuclear role in the mitigation of climate change, public relations and acceptance and international trends and cooperation are discussed. | 4 | |

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| Course No. 22 | Nuclear Reactor Experiments | 1 | This course provides for experiment/practice in nuclear reactor engineering and experiments in nuclear reactor use. The first topic covered includes operating procedures of nuclear reactors, console gauges, relation between reactivity and reactor cycle, control rod calibration, power calibration, measurement of fuel temperature coefficients, measurement of critical mass, the compensative effect of ion chamber, measurement of fuel ring coefficients and more. The second includes measurement of cadmium ratios, radioactivation analysis, isotope production, disposal of radioactive waste, health physics experiment and more. | 4 | |
| Course No. 23 | Introduction to Plasma Engineering | 3 | In this course, the basics of plasma engineering are covered as they apply to space, new material, semiconductor, environmental and fusion technologies including the definition of plasma, motion of a single charged particle, fluid theory, wave phenomenon and diffusion and transport. | 4 | |
| Course No. 24 | Radiological Safety Assessment | 3 | This course discusses the methodology for assessment of external/internal exposure both at work and in the environment. Engineering judgment for dose prediction, behavior of radio nuclides in the environment and human body, the use of SEE tables and conversion factors, and regulatory protection standards are also involved. Health physics programs including personal monitoring are introduced. | 4 | |

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| Course No. 25 | Nuclear Reactor Physics | 3 | This course covers differential scattering cross section, neutron transport theory for neutron behavior analysis within the reactor core, one and multi-group neutron transport equations, neutron slowing down theory, calculation of neutron spectrum and spectrum and group constants. | 4 | |
| Course No. 26 | Commercial Nuclear Power Reactors | 3 | This course is basically on the fundamental theory of nuclear reactor operations and reactor structure, also including operating plants' present conditions, types, systems, electricity generation mechanism, safety features. | 4 | |
| Course No. 27 | Nuclear Rad-Waste Technology | 3 | This course talks about the types, sources and characteristics of radioactive wastes; high-level waste treatment, low-level waste, treatment of fuel assembly; structural materials, treatment of waste of spent fuel; shallow land disposal and geologic disposal methods, decontamination and decommissioning. | 4 | |
| Course No. 28 | Industrial Plasma Engineering | 3 | Plasma science is interdisciplinarily covering space, semiconductor new material, energy and environmental industries. Basic plasma display physics, basic plasma chemistry, plasma-material interaction, plasma sources, etching, implantation, spraying for semiconductor and material processing, plasma-facing component interaction in fusion device and plasma diagnostics are covered | 4 | |

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| Course No. 29 | Alternative Energy System | 3 | In this course, discussion topics include energy consumption and resources, problems associated with fossil fuel systems, greenhouse gases and climate change, air pollution and acid rain, nuclear energy as an alternative , the development of renew. | 4 | |
| Course No. 30 | Radiological Imaging | 3 | In this course, principles of image formation and processing, analog and digital image, transformation and reconstruction, concepts of MTF and pixel and the quality of images are discussed. A focus on medical imaging, special techniques to improve image quality and to reduce patient doses in medical radiography is also included. | 4 | |
| Course No. 31 | Nuclear Energy Seminar | 1 | Current topics on nuclear energy, may be general or specific, nuclear safety, reactor engineering, nuclear weapons and safe-guards are discussed by staff and invited speakers. | 4 | |
| Course No. 32 | Small/Medium Advanced Reactor Technology | 3 | This course includes an outline of reactor core structure, sensitivity analysis of core design parameters, reactivity control, power distribution analysis, nuclear data analysis, critical buckling analysis, cell calculation, thermal hydraulic analysis, burn up calculation, load following operation, application of core analysis codes, core design for small/medium sized reactors for soluble boron free operation and more. | 4 | |

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| Course No. 33 | System Safety Engineering | 3 | In this course, safety assurance of complex systems such as nuclear power plants, Multi-barrier defenses, single failure criteria, human factors, man-machine interfaces, systematic factors, safety culture, qualitative and quantitative safety goals, and safety regulation are discussed. Safety management which includes risk, accident and emergency managements is also discussed. | 4 | |