# Department of Nuclear and Radiation Engineering

The department of Nuclear and Radiation Engineering offers the following programs:

## 1. Graduate Diplomas

### 1.1 Specialized Graduate Diploma in Nuclear Power Plants

The student must complete 30 credit hours.
Compulsory courses: The student must pass six courses with a total of 18 credit hours with course numbers (07 17 601, 07 17 611, 07 17 612, 07 17 613, 07 17 614, 07 17 631).
Elective courses: The student can choose the remaining credit hours from the following courses (07 17 622, 07 17 623, 07 17 624, 07 17 625, 07 17 626, 07 17 629).

### 1.2 Specialized Graduate Diploma in Nuclear Radiation and Environment

The student must complete 30 credit hours.
Compulsory courses: The student must pass six courses with a total of 18 credit hours with course numbers (07 17 602, 07 17 622, 07 17 624, 07 17 625, 07 17 626, 07 17 629).
Elective courses: The student can choose the remaining credit hours from the following courses (07 17 611, 07 17 621, 07 17 623, 07 17 627, 07 17 628, 07 17 631, 07 17 641).

## 2. Master Degrees

### 2.1 Master of Science in Nuclear and Radiation Engineering

The student must complete 24 credit hours in the form of courses and an additional 8 credit hours in the form of a thesis.
The student must choose from the following courses (07 17 710, 07 17 711, 07 17 712, 07 17 713, 07 17 714, 07 17 715, 07 17 716, 07 17 717, 07 17 718, 07 17 719, 07 17 721, 07 17 722, 07 17 723, 07 17 724, 07 17 725, 07 17 731, 07 17 732, 07 17 741).
The student is allowed to choose 2 courses from another major.

### 2.2 Master of Science in Nuclear Sciences and Technology

Students who want to enroll in the Master of Science in Nuclear Sciences and Technology program should have a B.Sc. in Science or Engineering. Students do not have to take non-credit courses from the B.Sc. level prior to admission to this program. In

order that the student obtains the Master of Nuclear Sciences and Technology, he/she must achieve 32 credit hours divided as follows:

1) 8 credit hours of thesis: 07 17 706
2) Compulsory Courses: 10 credit hours (07 17 751, 07 17 752, 07 17 753, 07 17 754, 07 17 755).
3) Elective Courses: 14 credit hours. The student must choose the required courses from one of the following lists:

A. Radiation Protection
(07 17 761, 07 17 762, 07 17 781, 07 17 782, 07 17 783, 07 17 784, 07 17 785, 07 17 786, 07 17 787, 07 17 788).
B. Nuclear Applications and Techniques
(07 17 761, 07 17 762, 07 17 771, 07 17 772, 07 17 773, 07 17 774, 07 17 775, 07 17 776, 07 17 777, 07 17 778).
C. Nuclear Engineering
(07 17 761, 07 17 762, 07 17 790, 07 17 791, 07 17 792, 07 17 793, 07 17 794, 07 17 795, 07 17 796, 07 17 797, 07 17 798, 07 17 799).

**3. Doctor of Philosophy- Ph.D. Degree**

**3.1 Doctor of Philosophy in Nuclear and Radiation Engineering**

The student must mplete 18 credit hours in the form of courses and an additional 24 credit hours in the form of a dissertation.
The student must choose from the following courses (07 17 811, 07 17 812, 07 17 813, 07 17 814, 07 17 815, 07 17 816, 07 17 817, 07 17 821, 07 17 822, 07 17 823, 07 17 824, 07 17 831, 07 17 832, 07 17 841).
The student has the right to choose another three courses from another major.

**List of Diploma, Master and Ph.D. courses (except for the Master of Nuclear Sciences and Technology)**

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| **1** | 07 17 611 | Transport Theory | 3 | 3 | |
| **2** | 07 17 612 | Advanced Nuclear Power Stations | 3 | 3 | |
| **3** | 07 17 613 | Heat Transfer in Nuclear Reactors | 3 | 3 | |

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| **4** | 07 17 614 | Nuclear Reactor Safety | 3 | 3 | |
| **5** | 07 17 621 | Radiation Damage in Materials | 3 | 3 | |
| **6** | 07 17 622 | Waste Management | 3 | 3 | |
| **7** | 07 17 623 | Transportation and Management of Radioactive Materials | 3 | 3 | |
| **8** | 07 17 624 | Environmental Aspects of Nuclear Energy | 3 | 3 | |
| **9** | 07 17 625 | Radiation Detection Techniques | 3 | 3 | |
| **10** | 07 17 626 | Radiation Protection | 3 | 3 | |
| **11** | 07 17 627 | Health Physics | 3 | 3 | |
| **12** | 07 17 628 | Advanced Applications of Nuclear Radiation | 3 | 3 | |
| **13** | 07 17 629 | Nuclear Environmental Pollution | 3 | 3 | |
| **14** | 07 17 631 | Nuclear Materials | 3 | 3 | |
| **15** | 07 17 641 | Environmental Protection | 3 | 3 | |
| **16** | 07 17 710 | Fusion Reactors Technology | 3 | 3 | |
| **17** | 07 17 711 | Neutron Transport Theory | 3 | 3 | |
| **18** | 07 17 712 | Nuclear Fuel Management | 3 | 3 | |
| **19** | 07 17 713 | Reactor Measurements and Control | 3 | 3 | |
| **20** | 07 17 714 | Economics of Nuclear Power Plants | 3 | 3 | |
| **21** | 07 17 715 | Reactor Experiments | 3 | 3 | |
| **22** | 07 17 716 | Special Topics in Nuclear Engineering | 3 | 3 | |
| **23** | 07 17 717 | Modeling and Simulation in Nuclear Engineering | 3 | 3 | |

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| **24** | 07 17 718 | Monte Carlo Applications in Nuclear Engineering | 3 | 3 | |
| **25** | 07 17 719 | Numerical Methods in Nuclear Engineering | 3 | 3 | |
| **26** | 07 17 720 | Nuclear Reactor Thermal Hydraulics | 3 | 3 | |
| **27** | 07 17 721 | Interaction of Radiation with Matter | 3 | 3 | |
| **28** | 07 17 722 | Plasma Processing | 3 | 3 | |
| **29** | 07 17 723 | Special Topics in Radiation Engineering | 3 | 3 | |
| **30** | 07 17 724 | Nondestructive Testing | 3 | 3 | |
| **31** | 07 17 725 | Radiation Detection Lab | 3 | 3 | |
| **32** | 07 17 726 | Nuclear Security and Safeguards | 3 | 3 | |
| **33** | 07 17 727 | Advanced Reactor Safety | 3 | 3 | |
| **34** | 07 17 728 | Design of Nuclear Power Plants | 3 | 3 | |
| **35** | 07 17 731 | Materials Characterization Techniques | 3 | 3 | |
| **36** | 07 17 732 | Fatigue in Engineering Materials | 3 | 3 | |
| **37** | 07 17 741 | Renewable Energy | 3 | 3 | |
| **38** | 07 17 811 | Advanced Reactor Theory | 3 | 3 | |
| **39** | 07 17 812 | New Trends and Features in Nuclear Power Plants | 3 | 3 | |
| **40** | 07 17 813 | Seminars in Nuclear Engineering | 3 | 3 | |
| **41** | 07 17 814 | Digital Simulation in Nuclear Engineering | 3 | 3 | |
| **42** | 07 17 815 | Monte Carlo Techniques in Nuclear Engineering | 3 | 3 | |
| **43** | 07 17 816 | Fusion Reactor Design | 3 | 3 | |

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| **44** | 07 17 817 | Reactor Kinetics and Control | 3 | 3 | |
| **45** | 07 17 821 | Advanced Plasma Physics | 3 | 3 | |
| **46** | 07 17 822 | Seminars in Radiation Engineering | 3 | 3 | |
| **47** | 07 17 823 | Charged Particles Accelerators | 3 | 3 | |
| **48** | 07 17 824 | Radiation Measurements Lab | 3 | 3 | |
| **49** | 07 17 831 | Composite Materials | 3 | 3 | |
| **50** | 07 17 832 | Radiation Effects in Nuclear Materials | 3 | 3 | |
| **51** | 07 17 841 | Desalination | 3 | 3 | |

**List of Diploma, Master and Ph.D. courses (except for the Master of Nuclear Sciences and Technology)**

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| 1 | 07 17 751 | Nuclear Physics | 2 | 2 | |
| 2 | 07 17 752 | Fundamentals of Nuclear Science and Engineering | 2 | 2 | |
| 3 | 07 17 753 | Radiation Detection and Measurements | 2 | 2 | |
| 4 | 07 17 754 | Radiation Protection and Shielding | 2 | 2 | |
| 5 | 07 17 755 | Computational and Simulation Methods in Physics | 2 | 2 | |
| 6 | 07 17 761 | Radiation Transport | 2 | 2 | |
| 7 | 07 17 762 | Mathematical Methods in Physics | 2 | 2 | |
| 8 | 07 17 771 | Optimization Principles and Techniques | 2 | 2 | |
| 9 | 07 17 772 | Radioisotopes and Designing of Radiogauges | 2 | 2 | |

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| 10 | 07 17 773 | Radiographic Testing and Technology | 2 | 2 | |
| 11 | 07 17 774 | Radioisotope Production | 2 | 2 | |
| 12 | 07 17 775 | Radioisotopes and Industrial Processes | 2 | 2 | |
| 13 | 07 17 776 | Diagnostics and Therapy Using Nuclear radiation | 2 | 2 | |
| 14 | 07 17 777 | Radioisotopes in Mining and Well Logging | 2 | 2 | |
| 15 | 07 17 778 | Applications of Radioisotopes in Agriculture | 2 | 2 | |
| 16 | 07 17 781 | International Regulations of Radiation Protection | 2 | 2 | |
| 17 | 07 17 782 | Assessment of Radiation Exposure | 2 | 2 | |
| 18 | 07 17 783 | Radiation Measurements and Dosimetry | 2 | 2 | |
| 19 | 07 17 784 | Radiation Sources and Irradiation Facilities | 2 | 2 | |
| 20 | 07 17 785 | Environmental Impact and Monitoring of Nuclear Radiation | 2 | 2 | |
| 21 | 07 17 786 | Design and Analysis of Shielding and Protection Facilities | 2 | 2 | |
| 22 | 07 17 787 | Radioactive Waste Management | 2 | 2 | |
| 23 | 07 17 788 | Biological Radiation Effects | 2 | 2 | |
| 24 | 07 17 790 | Advanced Nuclear Materials | 2 | 2 | |
| 25 | 07 17 791 | Research and Power Reactors | 2 | 2 | |
| 26 | 07 17 792 | Advanced Reactor Analysis | 2 | 2 | |
| 27 | 07 17 793 | Reactor Operation Experiments | 2 | 2 | |
| 28 | 07 17 794 | Reactor Parameters Measurements | 2 | 2 | |
| 29 | 07 17 795 | Instrumentation and Control of Nuclear Power Plants | 2 | 2 | |

| No. | Course Code | Course Name | Credit Hours | Exam Duration | Prerequisites |
|---|---|---|---|---|---|
| 30 | 07 17 796 | Reactor Thermal Hydraulics | 2 | 2 | |
| 31 | 07 17 797 | Fuel and Waste Management | 2 | 2 | |
| 32 | 07 17 798 | Computer Codes in Reactor Analysis | 2 | 2 | |
| 33 | 07 17 799 | Reactor Safety, Regulations and Safeguards | 2 | 2 | |

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|---|---|---|---|---|---|
| 34 | 07 17 601 | Diploma Project in Nuclear Power Plants | 3 | Presentation | |
| 35 | 07 17 602 | Diploma Project in Nuclear Radiation and Environment | 3 | Presentation | |
| 36 | 07 17 705 | M.Sc. Thesis in Nuclear and Radiation Engineering | 8 | Defense | |
| 37 | 07 17 706 | Master Thesis of Nuclear Sciences and Technology | 8 | Defense | |
| 38 | 07 17 801 | Ph.D. in Nuclear and Radiation Engineering Dissertation | 24 | Defense | |

## Description of Courses for Graduate Programs (Diploma- Master- Doctor of Philosophy)

**07 17 611 Transport Theory**
Transport equation. Exact solutions for simple-modeled systems. Nonlinear transport equation. Approximate solutions of the transport equation.

**07 17 612 Advanced Nuclear Power Stations**
Fast reactors technology. Fusion reactors. Evolutionary generation III, generation IV. Different reactor systems.

**07 17 613 Heat Transfer in Nuclear Reactors**
Heat transfer in reactor elements. Mixed two phase flow. Boiling. Critical heat flow. Boundary layer.

**07 17 614 Nuclear Reactor Safety**
Types of plants layout and physical structure. Concept of reactor protection system. Safety concepts. Introduction to reliability and fault, event tree analysis. Introduction to engineering safety feature systems. Markov chain for large multiplex system. Multi

attribute utility theorem and PSF for human errors. Introduction to artificial intelligence and operator machine interface problems.

**07 17 621 Radiation Damage in Materials**

Nature of disordered metals. Production of point defects. Mobility of point defects. Defect clusters in irradiated metals. Effect of irradiation induced defects on the mechanical properties of metals. The collision cascade. Computer experiment. Formation of binary collision approximation. The collision cascade and large displacements. Annealing and annihilation of defects. Ionic self-irradiation.

**07 17 622 Waste Management**

Production of nuclear waste. Strategies for waste disposal. Engineered multibarrier system. Waste-rock interactions. Isotope migration. Disposal sites. Burial technology. Study of burial site. Waste solidification, packaging, and transportation. Radionuclide transport models for shallow land burial sites monitoring. Spent fuel storage and disposal.

**07 17 623 Transportation and Management of Radioactive Materials**

Processing and storage of radioactive materials. Mmethods of assessing the environmental impact of radioactive materials. Regulations and licensing of radioactive materials (using, storage and transportation). Analysis of risks of routine transportation and transportation accidents.

**07 17 624 Environmental Aspects of Nuclear Energy**

Radiations releases from nuclear power plants (source term, dispersion, and dose assessment calculations). Thermal energy releases. Compatibility of nuclear plants with environmental architecture. Environmental data base analysis linked with dispersion codes. Review of International codes.

**07 17 625 Radiation Detection Techniques**

Slow neutron detection. Fast neutron detection methods. Cerenkov detectors. Liquid ionization and proportional counters. Photographic emulsion. Track-etch detectors. Foil activation multichannel analyzer. Low background detection.

**07 17 626 Radiation Protection**

Radiation sources. Radiation dosimetry. Recommended radiation levels. Determination of absorbed dose in man. Biological radiation effects on man. Applications of the numerical methods for the attenuation of gamma rays and neutron attenuation.

**07 17 627 Health Physics**
Introduction and historical review of the interaction of radiation with matter. Operational dosimetry. Shielding. Radiation detection theory. Radiation monitoring of personnel. Biological effects of radiation. Internal, external exposure and environmental dispersion.

**07 17 628 Advanced Applications of Nuclear Radiation**
Radioguaging. Radiography. Systems analysis. Oil logging. Radiation detectors. Nuclear medicine. Radiation therapy. Computer tomography. Imaging techniques.

**07 17 629 Nuclear Environmental Pollution**
Natural radioactive elements. Radioiodine pollution. Radiocesium and strontium pollution. Pollution with actinides. Pollution with short lived isotopes.

**07 17 631 Nuclear Materials**
Properties of U metal, U and Pu oxides. Crystal structure. Stoichiometry. Defects and fabrication. Fuel element thermal properties. Fuel chemistry. Solid fission products. Swelling and fission gas bubbles. Void swelling and creep. Properties of nuclear fuel. Fuel design for different reactors. Quality control and assurance.

**07 17 641 Environmental Protection**
Industrial waste treatment. Off gas treatment. Cleanup of polluted water resources. Reclamation of polluted soils. Decontamination. Other means of environmental protection.

**07 17 710 Fusion Reactors Technology**
Fusion reactions. Plasma firing. Reactor components: the plasma, the sheath, heating, cooling, the magnet, system for fuel charging, vacuum, the limiter, converter. Magnetic confinement. Inertial confinement.

**07 17 711 Neutron Transport Theory**
Neutron transport equation. Exact solutions for simple-modeled systems. Nonlinear transport equation. Approximate solutions of the transport equation.

**07 17 712 Nuclear Fuel Management**
Introduction to computational methods and theory. In-core fuel management using computer packages. Fuel management in different reactor systems. Optimization methods.

**07 17 713 Reactor Measurements and Control**
Methods of reactor control. Problems of control. Simulation of control. Reactor measurements.

**07 17 714 Economics of Nuclear Power Plants**
Review of economics of nuclear energy. Management of nuclear energy. Comparison of nuclear energy and alternative energy sources.

**07 17 715 Reactor Experiments**
Introductory experiment. Reactor operation experiments. Reactor engineering and technology experiments. Reactor physics experiments. Neutron physics experiments.

**07 17 716 Special Topics in Nuclear Engineering**
Lectures and recitation on recent advances in Nuclear Engineering.

**07 17 717 Modeling and Simulation in Nuclear Engineering**
Review of unified system of governing equations. Electronic analysis of engineering systems. Time and Laplace domain and relationship with frequency domain. Balance equation for mass, scale analysis in nuclear power plant models, and stiff system. Energy and momentum. Digital, analogue, electronic, and hybrid simulation techniques. Parity simulation techniques for different nuclear power plant systems. Data acquisition methods for NPP simulations and modeling. Modular structure for large scale system programming.

**07 17 718 Monte Carlo Applications in Nuclear Engineering**
Monte Carlo method and its applications. Neutron transport. Plasma transport. Radiation transport. Nonlinear transport equation. Rarified gas dynamics. Time scale for collisions. Limitations of the method. Other applications of Monte Carlo solution of finite difference equations.

**07 17 719 Numerical Methods in Nuclear Engineering**
Solution of linear equations. Roots of an equation. Numerical integration. Approximation theory. Curve fitting. Introduction to solution of differential equations.

**07 17 720 Nuclear Reactor Thermal Hydraulics**
Overview of nuclear reactor systems. Heat generation in reactors. Thermal constraints. Thermal hydraulic phenomena in LWRs. Heat transfer characteristics in single phase flow. Pool boiling and flow boiling. Governing equations for single phase convective heat transfer and its applications. Fundamental aspects of two phase flow. LOFA and LOCA.

**07 17 721 Interaction of Radiation with Matter**
Theory of electromagnetic interactions. Theory of atomic collisions. Passage of high energy charged particles through matter.

**07 17 722 Plasma Processing**
Plasma source ion implantation. Plasma etching. Plasma coatings. Plasma extractive metallurgy. Plasma chemistry. Electrical discharges in gases and arc technology.

**07 17 723 Special Topics in Radiation Engineering**
Lectures and recitation on recent advances in radiation engineering.

**07 17 724 Nondestructive Testing**
Principles of nondestructive testing. Nondestructive testing in the nuclear energy field. Eddy current methods and techniques. Ultrasonic methods and techniques. Radiation techniques.

**07 17 725 Radiation Detection Lab**
Different experiments for alpha, beta, gamma and neutron measurements.

**07 17 726 Nuclear Security and Safeguards**
The IAEA safeguards legal framework, Nuclear Nonproliferation Treaties (NPT), Effective implementation of safeguards**,** Safeguards measuring tools, control and accountancy of nuclear materials, Fundamental elements of nuclear security: deterrence, detection, response (DDR), nuclear security planning for nuclear and radiation facilities, physical protection systems of nuclear facilities, technology and equipment of physical protection, nuclear security cultures (concepts and models).

**07 17 727 Advanced Reactor Safety**
Safety systems and functions, safety analysis report and LOCA, probabilistic safety analysis, safety goals and risk informed decision making, integration of safety analysis into operational requirements, significant nuclear accidents.

**07 17 728 Design of Nuclear Power Plants**
Characteristics of design and operation of NNP, LIGHT AND HEAQVY WATER REACTORS, control system, features of steam generators, pressurizer and reactor pressure control, components outside the reactor island.

**07 17 731 Materials Characterization Techniques**
Principles of materials characterization. Sample preparation. Electron beam instruments. Electron-specimen interactions. Interpretation of diffraction information.

**07 17 732 Fatigue in Engineering Materials**
Influence of repeated stress in engineering design, fatigue testing machines and procedures, factors influencing fatigue properties, theory of fatigue failure.

**07 17 741 Renewable Energy**
Energy technology. Renewable energy and the future. Advantages and disadvantages. Limitations. Types of renewable energy: wind energy, solar energy, hydro-electric, bio-energy, tidal power, wave energy, geothermal energy, ocean thermal, fuel cells. The availability and integration of different energy types.

**07 17 811 Advanced Reactor Theory**
Neutron transport equation. One speed transport theory. Solution of the transport equation by multigroup methods. Perturbation theory. Neutron thermalization and resonance absorption.

**07 17 812 New Trends and Features in Nuclear Power Plants**
New trends and features in designing and building generation III+ , generation IV and Fusion reactors.

**07 17 813 Seminars in Nuclear Engineering**
The students attend and give lectures and recitations on recent advances in nuclear engineering.

**07 17 814 Digital Simulation in Nuclear Engineering**
System modeling of engineering systems. Implicit and explicit integration routines. Setting of the ordinary differential equations for system governing equations. Large scale system with delayed operator. Introduction of hybrid and electronic simulation. Graphical and interactive code structure for large simulation package. Fuzzy controller and data acquisition.

**07 17 815 Monte Carlo Techniques in Nuclear Engineering**
Monte Carlo method and its applications in Nuclear Engineering. Computer codes used in nuclear applications.

**07 17 816 Fusion Reactor Design**
Overview of the fusion reactor. Design of different fusion reactor systems and components. ITER features and design. New and planned fusion systems.

**07 17 817 Reactor Kinetics and Control**
Control of nuclear reactor systems. Development of basic control theory. Analysis of reactor and reactor systems using control methods. Development of control methods and optimum-control methods. Effects of nonlinearities.

**07 17 821 Advanced Plasma Physics**
Development of plasma kinetic theory. Collision processes. Orbit and hydrodynamic theory. Equilibrium and stability. Nonlinear effects. Waves in cold and hot plasmas. Landau damping. Cyclotron damping. Magnetohydrodynamic equilibria and instabilities. Introduction to nonlinear processes.

**07 17 822 Seminars in Radiation Engineering**
The students attend and give lectures and recitation on recent advances in radiation engineering.

**07 17 823 Charged Particles Accelerators**
Historical review to accelerators theory. Classical dynamics to thermal theory and relativistic mechanics. Types of accelerators. Calculations in orbital theory. Applications of accelerators. Synchrotron radiation sources.

**07 17 824 Radiation Measurements Lab**
Different experiments for detection and measurements of alpha, beta, gamma and neutron radiation.

**07 17 831 Composite Materials**
Physical and mechanical properties of polymers, metals, ceramics, cementitious, and biological composite systems. Lamination and strength analyses. Static and transient loading. Fabrication, recycling, design and applications of composite materials.

**07 17 832 Radiation Effects in Nuclear Materials**
Radiation effects in solids. Defect production. Radiation effects on materials: creep, hardening, fracture, fatigue, void swelling and creep.

**07 17 841 Desalination**
Flash desalination. Multistage flash evaporation. Vapor compression desalination. Solar desalination. Freezing hydrate processes. Solvent extraction. Membrane processes. Reverse osmosis. Electrodialysis. Ion exchange processes. Desalination plant. Nuclear energy in desalination. Economics of desalination processes.

## Description of Courses for the Master of Nuclear Sciences and Technology

**07 17 751 Nuclear Physics**
Radioactivity. Elements of nuclear structure. Alpha, beta and gamma radiation. Nuclear reactions. Nuclear models. Cross sections and nuclear data processing. Fission and fusion.

**07 17 752 Fundamentals of Nuclear Science and Engineering**
Neutron interaction with matter. The nuclear chain reaction. The nuclear fuel cycle. Nuclear reactors. Radioisotopes production and utilization.

**07 17 753 Radiation Detection and Measurements**
Interaction of nuclear radiation with matter (heavity and light charged particles, neutrons, x-ray and gamma rays). General properties of detectors. Types of detectors. Spectroscopy and spectra unfolding. Pulse signal processing. Detector systems. Detector calibration.

**07 17 754 Radiation Protection and Shielding**
Introduction to atomic structure. Application of radionuclide (medical, industrial, agriculture, research and training). Dosimetric quantities and units. Biological effect of radiation. Scope of basic legal frame work of radiation protection. Internal, external and effective dose. Principles of shielding.

**07 17 755 Computational and Simulation Methods in Physics**
Numerical integration. Iterative methods. Monte Carlo method. Finite difference methods. Finite element methods. Interpolation and approximation methods. Numerical solution of linear and non-linear systems. Concepts of computer modeling and simulation.

**07 17 761 Radiation Transport**
Point kernel technique. Boltzmann transport equation. The Monte Carlo method. Moments method. Discrete ordinate method. Application to neutron transport, plasma physics, photon transport, electron conduction in solids.

**07 17 762 Mathematical Methods in Physics**
Fourier and Laplace transformations. Special and orthogonal functions. Variation principle and optimization methods. Eigenvalues and Eigenvectors.

**07 17 771 Optimization Principles and Techniques**
Fundamental optimization methods. Linear and quadratic programming. Integer programming. Network models and dynamic programming methods of operations research. Unconstrained optimization methods. Nonlinear equations. Constrained optimization methods. Convex optimization. Global optimization. Parallelism in optimization.

**07 17 772 Radioisotopes and Designing of Radiogauges**
Methodology of using radioisotopes. Application of radioisotopes (industry, agriculture, medicine, environment). Nondestructive control. Dating using radioactivity. Forensic methods. Applications of radiotracers.

**07 17 773 Radiographic Testing and Technology**
Introduction to radiography. Radiography equipment and installations. Welding techniques. Metal materials. Classification of flaws. Codes and standards. Safety aspects.

**07 17 774 Radioisotopes production**
Radioisotope production for medical and industrial purposes. Radionuclides generation and separation. Purification and constraints for manufacturing a radiopharmaceutical product. Waste management. Conceptions of hot cells and ventilation systems. Maintenance of installations. Safety, environmental and pertinent issues in cases of normal operation and emergency.

**07 17 775 Radioisotope and Industrial Processes**
Radiation technology utilizing gamma or x-ray sources and electron accelerators (material modification, sterilization, food irradiation, polymer/rubber processing). Applications of radiotracers and sealed sources (production, control and quality enhancement). Nondestructive testing. Radiography. Neutron activation analysis.

**07 17 776 Diagnostics and Therapy Using Nuclear Radiation**
Diagnostic imaging (radiography, computed tomography, nuclear medicine). Dosimetry of radiation fields (percent depth dose, dose calculations for rotational therapy, isodose curves, treatment planning, point dose calculations, dose calculations for irregular fields.

**07 17 777 Radioisotopes in Mining and Well Logging**
Neutron and gamma-ray sources. Review of radiation detection methods. Lithology, porosity and fluid characteristics of materials. Computer simulation with neutrons and gamma-ray transport codes. Optimization techniques. Experimental applications.

**07 17 778 Applications of Radioisotopes in Agriculture**
Techniques for developing new plant species. Pest control. Reducing fertilizer consumption. Killing insects and rodents. Destroying bacteria. Viruses and molds in food.

**07 17 781 International Regulations of Radiation Protection**
Scope of basic legal frame work of radiation protection. Legislative framework. The regulatory authority. Regulatory system. Regulatory assessment. Preparedness for emergencies and accidents.

**07 17 782 Assessment of Radiation Exposure**
Safety and security of sources. Safety of transport and storage of radioactive waste management. Environmental monitoring. Individual and workplace monitoring. Basic concepts for emergency preparedness for a nuclear accident or radiological emergency. Training of personnel. Exposure in the industry and in the medical fields.

**07 17 783 Radiation Measurements and Dosimetry**
Radiometric quantities and interaction coefficients. Radiation protection quantities. Dosimetric calculations. Atomic absorption spectroscopy. X-ray fluorescence. Neutron activation analysis. Particles induced x-ray emission. Mossbauer spectrometry. Beta counting systems. Alpha spectrometry. Gamma spectrometry.

**07 17 784 Radiation Sources and Irradiation Facilities**
Different uses of irradiation processes. Types of irradiation facilities (irradiation using alpha, beta, gamma, neutrons, x-rays). Radiation sources used in irradiation processes.

**07 17 785 Environmental Impact and Monitoring of Nuclear Radiation**
Monitoring at source (external radiation and liquid and gaseous effluents, verification of compliance with discharge limits). Environmental monitoring (atmosphere, water bodies, foodstuff, other environmental indicators). Verification of compliance with derived environmental reference levels, survey techniques. Application to different sources (NPP, waste facilities, including repositories, mining and milling, tailings, contaminated land).

**07 17 786 Design and Analysis of Shielding and Protection Facilities**
Design features. Ventilation systems. Shielding calculations (safety interlocks, remote handling equipment, fume hoods, hot cells, glove boxes, changing rooms, physical barriers, storage facilities, liquid effluent pipeline and decay control, fixed radiation monitors, warning signs, quality assurance). Commissioning survey and regulatory review. Shielding calculations for (x-ray facility, cobalt therapy room, accelerator room).

**07 17 787 Radioactive Waste Management**
Sources of radioactive waste. Waste types: classification and characterization. Principles of radioactive waste. Waste minimization. Pre-disposal waste management (collection, segregation, treatment, conditioning, secure storage). Management of waste from decommissioning. Solid waste disposal. Environmental dose assessment.

**07 17 788 Biological Radiation Effects**
Basic radiation chemistry. Effects of radiation on cells. Deterministic effects (effects of whole body irradiation, effects of partial body irradiation). Stochastic effects. Effects on the embryo and the fetus. Hereditary effects and radiation detriment.

**07 17 790 Advanced Nuclear Materials**
Properties and selection of materials for nuclear systems. Implications of radiation damage and effects to reactor materials. Material problems in nuclear engineering.

**07 17 791 Research and Power Reactors**
Characteristics of a nuclear reactor system. Gas type reactors (Magnox, AGR, RBMK). Light water reactors (PWR, BWR, VVER). Heavy water reactors (Candu, SGHWR, EL4). Fast breeder reactors. High temperature reactors. New projects (EPR, ABWR, SBWR, AP600). Other projects (ADS, Molten salts, GEN IV). Research reactors and their applications.

**07 17 792 Advanced Reactor Analysis**
Review of nuclear physics. Interaction of neutrons with matter. Nuclear fission (chain reacting systems, neutron diffusion). Neutron moderation without absorption. Neutron moderation with absorption and fission. Low energy neutrons. Fermi theory for the bare thermal reactors. Multiregion reactors (the group diffusion method, the multigroup diffusion). Transport theory. Diffusion approximation. Perturbation theory. Reactor kinetics. Heterogeneous reactors. Changes in reactivity.

**07 17 793 Reactor Operation Experiments**
Introduction and approach to critical, control rod calibration and worth measurements. Power calibration. Temperature, coefficient of reactivity and reactivity measurements.

**07 17 794 Reactor Parameters Measurements**
Flux mapping. Time and space dependence of neutron flux using pulsed neutron techniques. Neutron age in water. Measurement of diffusion parameters of moderator. Importance function for neutron absorbers.

**07 17 795 Instrumentation and Control of Nuclear Power Plants**
Basic instrumentation (temperature, pressure, flux, vibration). Basics of control. Classification of instrumentation and control systems (defense in depth, independence, single failure criterion, reliability, testability, specific design criteria for computer-based systems, qualification and validation, IAEA safety guides). Contemporary methods for data evaluation (databases, testing of reliability estimation based on databases, stochastical methods). Examples of nuclear instrumentation in NPP.

**07 17 796 Reactor Thermal Hydraulics**
Heat generation in the reactor. Transport equations (single- and two-phase flow). Thermal analysis of the fuel elements. Two-phase flow dynamics. Single heated channel (steady state and transient analysis). Flow loops. Computer codes. The pressurizer

behavior in a PWR. Temperature distribution in irradiation rigs. The reactor in case of a LOCA and MSLB.

**07 17 797 Fuel and Waste Management**

Components and material flow sheets for nuclear fuel cycle. Fuel management inside the reactor. Waste characteristics, sources of radioactive wastes. Compositions and classification. Radioactivity and heat generation. Waste treatment technologies. Waste disposal technologies. Safety assessment of waste disposal.

**07 17 798 Computer Codes in Reactor Analysis**

Solving the diffusion equation using multigroup method. Solution of the transport equation. Principles of programming and software. Exercises on reactor core and shielding codes.

**07 17 799 Reactor Safety, Regulations and Safeguards**

Principles and safety related systems. Deterministic safety analysis. Accidents and transients. Analysis of consequences. Physical protection and protection systems. Requirements and conditions for licensing of nuclear facilities. Basic safeguards principles and approaches. National and international laws and treaties.

**07 17 601 Diploma Project in Nuclear Power Plants**

**07 17 602 Diploma Project in Nuclear Radiation and Environment**

**07 17 705 M.Sc. Thesis in Nuclear and Radiation Engineering**

**07 17 706 Master of Nuclear Sciences and Technology Thesis**

**07 17 801 Ph.D. in Nuclear and Radiation Engineering Dissertation**