Curriculum

MS Radiation Physics

DEPARTMENT OF NUCLEAR ENGINEERING

PAKISTAN INSTITUTE OF ENGINEERING AND APPLIED SCIENCES (PIEAS)

NILORE, ISLAMABAD

SEMESTER-WISE COURSE PLAN
SUMMARY

Spring Semester	**NE-501 Fundamental of Nuclear Engineering**	**NE-535 Radiation Interaction and Detection**	**CMS-504 Communication & Public Relation Skills**	**NE-599 Environmental Engineering**	
Summer Session	**NE-507 Radiological Engineering**	**NE-504 Radiation Measurement Laboratory**			
Fall semester	**NE-510: Nuclear Power Plant Systems**	**NE-605 Radiation Shielding**	**NE-641 Meteorology and Radioactive Effluent Dispersion**	**NE-610 Reliability and Risk Assessment**	**NE-XXX **Optional Course-1**
Spring Semester	**NE-614 Radioactive Waste Management**	**NE-643 Nuclear Emergency Management**	**NE-XXX **Optional Course-2**	**NE-696 Project work**	
Project work	**NE 696: MS Radiation Physics Project**				

****Optional Course may be any course from the list of approved courses of DNE**

MS (RP) Course Minimum Requirement: 43 CH of course work and 15 CH of Project Work.

DETAILED SEMESTER-WISE COURSE PLAN

Note: *'C' and 'O' stand for 'Compulsory' and 'Optional', respectively*

SPRING SEMESTER - I					
1	NE-501	Fundamentals of Nuclear Engineering	3	C	Nil
2	NE-535	Radiation Interaction and Detection	3	C	Nil
3	CMS-504	Communication & Public Relation Skills	3	C	Nil
4	NE-599	Environmental Engineering	3	C	Nil
SUMMER SESSION –SEMESTER-II					
5	NE-507	Radiological Engineering	3	C	Nil
6	NE-504	Radiation Measurement Laboratory	3	C	NE-535
FALL SEMESTER-III					
7	NE-510	Nuclear Power Plant Systems	3	C	NE-501
8	NE-605	Radiation Shielding	3	C	NE-501, 507
9	NE-641	Meteorology & Radioactive Effluent Dispersion	3	C	NE-599
10	NE-610	Reliability and Risk Assessment	3	C	NE-501
12	NE-XXX	**Optional Course - I	3	O	Accordingly
SPRING SEMESTER - IV					
13	NE-614	Radioactive Waste Management	3	C	NE-501, 507
14	NE-643	Nuclear Emergency Management	4	C	NE-641, 599
17	NE-XXX	**Optional Course - II	3	O	Accordingly
18	NE-696	Project Work	3	C	Nil
SUMMER SEMESTER - V					
19	NE-696	Project Work (placement at PAEC sites for practical training) work)	12	C	Nil

****Optional Course may be any course from the list of approved courses of DNE**

MS (RP) Course Minimum Requirement: 43CH of course work and 15 CH or thesis Project.

Detailed Course Contents

NE-501: FUNDAMENTALS OF NUCLEAR ENGINEERING

Nuclear cross-sections; Reaction rates; Nuclear fission and chain reaction; Criticality conditions; Neutron moderation; Thermal Neutron Spectra, Neutron Diffusion in non-multiplying media; The one-speed diffusion model of a nuclear reactor, Conversion and breeding, Reactor components and their characteristics; Design features of research, production, and power reactors, Introduction to fast and fusion reactor systems; Nuclear materials; Uranium Enrichment; Fabrication of fuel; Reprocessing of irradiated fuel; Process waste disposal. Reactor fuel requirements; Introduction to Nuclear Fuel Cycle, Burn up studies of nuclear fuels; Fuel cycle performance of commercially available reactors; In-core fuel management & strategies, Radioisotopes production & applications in various fields.

References:

1. Lamarsh, J.R and Anthony J. Baratta, 3rd Ed., Introduction to Nuclear Engineering, Prentice Hall. 2001.
2. Murray, R. L.; Nuclear Energy, An introduction to the concepts, systems, and Applications of Nuclear Processes, 6th Ed., Elsevier, 2009.
3. Shultis, J.K. and Faw, R. E. ; Fundamentals of Nuclear Science and Technology, Marcel Dekker Inc, 2002.
4. Glasstone, S. and Sesonske, A., Nuclear Reactor Engineering, 4th Ed., Springer, 1994.
5. Rahman, I.U. and P.S. Sheikh, Introduction to Nuclear Engineering, Krieger, 1981.
6. Graves, H.W., Jr., Nuclear Fuel Management, John Wiley, 1979

NE-535: RADIATION INTERACTION AND DETECTION

Radiation sources; Interaction of radiation with matter, Basic principles of radiation detection; Design aspects of ionization chambers, Proportional and Geiger-Muller counters, Various types of scintillators; Scintillation detectors, Radiation spectroscopy using Scintillation detectors, Semiconductors, Various types of semiconductor detectors and their characteristics, Neutron sources, detection techniques and neutron spectroscopy, Basic electronic circuits and electronic equipment used in nuclear radiation detection systems, Counting statistics including probability distributions (discrete & continuous); curve fitting and tests for goodness of fit; errors and their propagation.

References:

1. Knoll, G.F., Radiation Detection and Measurement, John Wiley, 1989.

2. Tsoulfanidis , N., Landsberger, S, Measurement and Detection of Radiation, 3rd Ed, CRC Press, 2010
3. Turner,J.E., Atoms, Radiations and Radiation Protection, Willey-VCH,2004.
4. Shultis, J, K and Faw, R.E., Fundamentals of Nuclear Science and Engineering, Marcel Dekker, Inc., 2002.

NE-641: METEOROLOGY AND RADIOACTIVE EFLUENT DISPERSION

Introduction to Meteorology, Air pressure and Winds, Circulation of the Atmosphere, Temperature, Moisture and Atmospheric Stability, Weather Pattern, Thunderstorms, Tornadoes and Hurricanes, Weather Analysis and forecasting, Monsoons and Weather of South Asia. Meteorological factors affecting pollution dispersion; Calculation of source term, Physical principles of atmospheric transport processes. Variation of transport in time and place, Local and regional concentrations of pollutants,Steady state solution of the diffusion equation; Gaussian plume model for point, line and area sources; Calculation of plume rise; Trajectory analysis and long range transport; Emission inventories; Dispersion of pollutants released into water bodies and soil; Pollutants dispersion modeling in air and surface waters. Eulerian & Lagrangian dispersion modeling concepts, Meso-scale Meteorological Models and GPM using computational tools.

References:

1. Turner, D.B. (1994). Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modeling, 2nd Edition, CRC Press.
2. Arya, S. Pal (1998). Air Pollution Meteorology and Dispersion, 1st Edition, Oxford University Press
3. Cooper, J.R., Randle, K. and Sokh, R.G (2003). Radioactive Releases in the Environment, 1st Edition, John Wiley & Sons.
4. Pielke, Roger A. (2001). Mesoscale Modeling, 2nd Edition, Elsevier.
5. Beychok, Milton R. (2005). Fundamentals of Stack Gas Dispersion, 4th Edition, author-published.
6. Perianez, Raul (2005). Modelling the dispersion of radionuclides in the marine environment : an introduction, 1st Edition, Springer.

NE-599: ENVIRONMENTAL ENGINEERING

Current environmental issues; Environmental monitoring and surveys, Radioactive effluents from nuclear power plants and other allied nuclear industries; radioactivity transfer via food chains and critical pathways to man; Health Impact, Radiation safety guides and regulations to workplace and public exposure scenarios, population dose calculation, Sampling and monitoring of pollutants/Contaminants in various matrices; EIAs of NPPs, NPP ventilation system, Filtered Containment Vent System, Control of Hazardous Air Pollutants (HAPs), Particulates and Gaseous Effluent Treatment Processes, Management of liquid and solid radioactive, Concept of coupling of meteorological and dispersion models.

References:

1. Keily Gerard, Environmental Engineering, International Edition, McGraw Hill, 1998.
2. Lee, C.C. and Lin, S., Handbook of Environmental Engineering Calculations 2nd Ed, McGraw Hill, 2007.
3. Shaw G., Radioactivity in Terrestrial Environment, Elsevier Science, 2007
4. Eisenbud, M., Gessel. T., Environmental Radioactivity from Natural, Industrial & Military Sources, Academic Press; 4th Ed, 1997.
5. Wang L, K, Pereira, N.C, Hung Y.T., Air Pollution Control Engineering, Humana Press, 2004
6. Eichholz, G.G.: Environmental Aspects of Nuclear Power, Ann Arbor Science, Inc., 1976.

NE-507: RADIOLOGICAL ENGINEERING

Radiation sources; Biological effects of radiation; Radiation units; Standards of radiation protection; Calculation of exposure and dose, Principles, working and selection of Health Physics Instruments for personal dosimetry and environmental surveillance, Nuclear instrumentation modules used with various radiation detectors; Attenuation coefficients and build-up factors gamma-rays; Shielding of sources with different geometrical shapes;Shields with internal sources; Multilayered Concept of removal cross-sections; Removal-attenuation and removal diffusion calculations; Principles of shielding. Safety features of nuclear power plants; Reactor siting; Reactor accident risk analysis. Assessment of Source Term and Release Characteristics, Determination of Exclusion Area, Low Population Zone (LPZ), Emergency Planning Zone (EPZ), Precautionary Action Zone (PAZ), Urgent Protective Action Zone, Dispersion of effluents from nuclear facilities; Radiation doses from nuclear plants; Radiological Assessment Systems for Consequence AnaLysis Code RASCAL, PAVAN, HOTSPOT etc.

References:

1. Lamarsh, J.R and Anthony J. Baratta, 3rd Ed., Introduction to Nuclear Engineering, Prentice Hall. 2001.
2. Hall, E. J., Giacia, A., Radiobiology for the Radiologist, 7th Ed., Lippincott Williams & Wilkins; 2011.
3. Cember, H., Johnson, T., Introduction to Health Physics, 4th Ed., McGraw Hill, 2008.
4. Turner,J.E., Atoms, Radiations and Radiation Protection, Willey-VCH,2004.
5. Johnson, T.E., Birky, B. K., Health Physics and Radiological Health, Lippincott Williams & Wilkins; 2011.
6. Jaeger, RG. Engineering Compendium on Radiation Shielding, Springer-Vela, 1970.

CMS-504: COMMUNICATION AND PUBLIC RELATION SKILLS

Writing Module: Preparation of a project proposal or technical report, Writing letters, mission statements, office memos, Persuasive writing and communication process; Effective use of email, memos, letters, reports and proposals; Development of a news release in writing and in video for broadcast media; Writing public speeches & presentations; Development of newsletters, brochures, and annual reports, **Speaking Module:** Presentation of the project proposal or technical report, development of a media strategy for a proposed crisis, **Listening Module:** Simulations of interviews, lectures and question-answer sessions.

References:

1. Eric H. Glendinning and Norman Glendinning. "English for Electrical and Mechanical Engineering", Oxford University Press, 1995
2. Huckin and Oslen. "Technical Writing and Professional Communication for Non-native Speakers of English" (Int'l Edition, 2nd Edition), McGraw Hill, 1991
3. John M. Swales and Christine B. Feak. "Academic Writing for Graduate Students, A Course for Non-native Speakers of English", Uni. of Michigan Press, 2004

NE-504: RADIATION MEASUREMENT LABORATORY

Nuclear Electronics, Counting Statistics using G.M. Detector, Half Life Measurement, Low level activity measurement using Liquid Scintillation Detector, Decontamination Procedures, Determination of environmental radioactivity using HPGe detector, Low level alpha-beta counting system study and environmental monitoring, Determination of attenuation coefficient and build-up factor for single and multilayered shields, Study of the shielding characteristics of single and laminated materials for gamma-rays, Shielding characteristics of different materials for gamma & fast neutrons. Characteristics of a NaI (TI) scintillation detector and pulse height spectrum of gamma sources, Determination of source strength using gamma-gamma or beta-gamma coincidence method.

References:

1. Nasir Ahmad and Tahir Mahmood, Experiments in Reactor Physics and Reactor Shielding, CNS- 12, 1982.
2. Nasir Ahmad, Experimental Radiation Detection, CNS-20, 1988.
3. Profio, A.E., Experimental Reactor Physics, John Wiley, 1976.
4. Holman, J.P., Exp. Methods for Engineers, McGraw-Hill, 1984.
5. Kreith, F., Principles of Heat Transfer, Intext Press Inc., 1976.
6. Dally, J.W. and W. F. Riley, Experimental Stress Analysis, McGraw-Hill, 1978.
7. Knoll, G.F., Radiation Detection and Measurements, John Wiley, 1989.
8. Price, W.J., Nuclear Radiation Detection, McGraw-Hill, 1964.

NE-605: RADIATION SHIELDING

Isotropic and anisotropic shields for extended radiation sources; Calculation methods used in shielding; Effects of ducts and voids in shields; Streaming and backscattering of radiation; Heat generation by radiation in shields. Materials for shielding and their nuclear, physical, and mechanical properties and technology; Shield design and engineering research and NPPs; Large radiation sources; Transport containers; Reprocessing plants; Waste storage facilities & shielded cells; Experimental facilities for shielding studies.

References:

1. Chilton, A B., Shultis, J. K. and R E. Faw, Principles of Radiation Shielding, Prentice-Hall, 1984
2. Schaeffer, N. M. (ed), Reactor Shielding for Nuclear Engineers, Technical Information Center, USAEC, 1973
3. Goldstein, H., Fundamental Aspects of Reactor Shielding, Pergamon, 1959.
4. Rockwell, T., Reactor Shielding Design Manual, Springfield National Technical Information Services 1956.
5. Jaeger, RG. and E.P. Blizard (eds.), Engineering Compendium on Radiation Shielding Vol. 1, 11 and, 111, Springer- Verlag, 1970.

NE-510: NUCLEAR POWER PLANT SYSTEMS

Layout of nuclear power plants; Containment buildings; Primary containment vessels; Structure of reactor core; Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps ,turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control mechanisms; Radwaste systems; Electrical Systems; Reactor grid interface & load following. Basics of NPP design; Dual & multipurpose nuclear plants; Future trends i.e. INPRO and SMRs.

References:

1. Rust, J. H., Nuclear Power Plant Engineering, Haralson, 1979.
2. El-Wakil, M.M., Nuclear Energy Conversion, International Text Book, 1982
3. Pedersen, E.S., Nuclear Power, Ann Arbor Science, 1978.
4. El-Wakil, M.M., Power Plant Technology, McGraw-Hill, 1984.
5. Lish, K.C., Nuclear Power Plant Systems & Equipment, Industrial Press Inc., 1972.

NE-642: NUCLEAR FUEL CYCLE

Overview of the fuel cycle, Mining and milling of uranium, Purification and conversion to UF_6, available technologies for uranium enrichment, Fuel fabrication and testing, In core fuel management, Fuel utilization: energy production and burnup estimation, spent fuel and its inventory calculations, Properties of irradiated fuel, Irradiated fuel transport and storage, Nuclear fuel reprocessing, Recycling of uranium and plutonium, Physical and chemical characterization of nuclear material for safeguards and forensics, Mixed oxide fuel (MO_x), Radioactive waste management of low, medium and high-level waste, Retrieval and disposal of nuclear waste, decommissioning of nuclear

reactor, Emerging fuel technologies, R&D in the field of the long-lived nuclear waste management : advanced separation, transmutation and long-term interim storage, Policy issues and proliferation concerns, including the role of the IAEA and national regulatory bodies in safeguarding the nuclear fuel cycle

References:

1. N. Tsoulfanidis, The Nuclear Fuel Cycle, La Grange Park, Ill.: ANS, 2013.
2. Mary Beth Nikitin, Anthony Andrews, Mark Holt, Managing the Nuclear Fuel Cycle: October 19, 2012.
3. Ian Crossland, Nuclear Fuel Cycle Science and Engineering, Woodhead Publishing Limited, 2012.
4. Managing the Nuclear Fuel Cycle; Policy implications of Expanding Global Access to Nuclear Power, Mary Beth Dunham Nikitin, Anthony P. Andrews, Mark Holt, Congressional Research Service, 2010.
5. NEA, Advance Nuclear Fuel Cycles and Waste Management, 2006.
6. IAEA-TECDOC-1613, Nuclear Fuel Cycle Information System, 2009.

NE-610: RELIABILITY AND RISK ANALYSIS

Reliability concepts; Probability distributions for describing failures; Failure data; Sampling, estimation and confidence limits; Reliability of simple systems; Synthesis of reliability for complex systems; Fault tree analysis; Event tree analysis Concepts of risks; Risk analysis for nuclear reactors; Risk analysis for the various stages of the nuclear fuel cycle; Comparison of nuclear risks to risks from other energy sources; Risk benefit and cost-benefit analysis.

References:

1. McCormick, N.J., Reliability and Risk Analysis: Methods and Nuclear Power Applications, Academic, 1981.
2. Green, A.E., Safety Systems Reliability, John Wiley, 1983.
3. Lakner, A.A. and RT. Anderson, Reliability Engineering for Nuclear and other High Technology Systems, Elsevier 1985.
4. Billinton, R, and RN. Allan, Reliability Evaluation of Engineering Systems, Pitman, 1983.
5. WASH-1400, Reactor Safety Study, U.S. Nuclear Regulatory Commission, 1975.
6. NUREG-0492, Fault Tree Handbook, U.S. Nuclear Regulatory Commission, 1981.

NE-581: NUCLEAR SECURITY

Introduction to nuclear safety and security; National infrastructure for nuclear security; Knowledge of national/international nuclear laws; International conventions & treaties on nuclear safeguards; Introduction to IAEA's safeguards system: types, requirements, implementation, verification and evaluation; Categorization, applications, vulnerability, security of radioactive materials and facilities; Basics of nuclear materials accounting and control; Overview of an export control system; National/International control lists; Introduction to international nuclear security initiatives; Introduction to border monitoring systems, types, assessment, localization and identification,

verification of alarms; Illicit trafficking of nuclear materials; Causes of nuclear terrorism.

References:

1. James E. Doyle (editor), Nuclear Safeguards, Security and Nonproliferation, Butterworth-Heinemann, New York, 2008.
2. Sarah J. Diehland, and James Clay Moltz, Nuclear Weapons and Nonproliferation: A Reference Handbook, ABC CLIO Publishers, Oxford, England, 2002.
3. Randall Forsberg, William Driscoll, Gregory Webb , and Jonathan Dean, Nonproliferation Primer: Preventing the Spread of Nuclear, Chemical, and Biological Weapons, The MIT Press, Cambridge, London, 1995.
4. International Atomic Energy Agency, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA/CODEOC/2001, IAEA, Vienna, 2001.
5. International Atomic Energy Agency, Guidance on Import and Export of Radioactive Sources, IAEA/CODEOC/IMP-EXP/2005, IAEA, Vienna 2005.
6. International Atomic Energy Agency, Handbook on Nuclear law, IAEA, Vienna, 2003.
7. International Atomic Energy Agency, IAEA Nuclear Security Series No. 1 to 11, IAEA, Vienna, 2009.
8. PNRA, Regulations on Licensing of Nuclear Installations, PAK/909, Pakistan Nuclear Regulatory Authority (PNRA), Islamabad, Pakistan, October, 2001.
9. PNRA, Regulations on Radiation Protection, PAK/904, Pakistan Nuclear Regulatory Authority (PNRA), Islamabad, Pakistan, October 2004.
10. PNRA, Regulations on Safety of Nuclear Power Plants/Operations, PAK/913, Pakistan Nuclear Regulatory Authority (PNRA), Islamabad, Pakistan, December 2004.

NE-614: RADIOACTIVE WASTE MANAGEMENT

Build-up and decay of radioactive nuclides; Major sources of nuclear waste; Gaseous, liquid and solid wastes; High level liquid waste, its characterization and projections for fuel cycle; Commercial high level liquid waste management; Solidification processes and products; Actinide partitioning of high level liquid waste; Low and medium level wastes and their treatment in gaseous, liquid & solid forms; Special wastes of tritium, krypton and iodine isotopes; Considerations of ultimate disposal of nuclear wastes; Assessment of long term safety; Design of a waste processing facility.

References:

1. Benedict. , T.H Pigford and HW. Levi, Nuclear Chemical Engineering, McGraw-Hill, 1981.
2. Mawsor, G.A., Management of Radioactive Wastes, Van Nostrand, 1965.

3. Proceedings of the Management of Radioactive Wastes from the Nuclear Fuel Cycle, IAEA, Vienna, 1976.

NE-643: NUCLEAR EMERGENCY MANAGEMENT

Nuclear emergency types, Comparison of Chernobyl, Fukushima and other accidents, Consequence management after a nuclear accident, preparedness and response to radiological emergency and emergency monitoring, Goals of Emergency response and preparedness, Requirement for infrastructure, Role of NURESC, DGS, PNRA, Mobile Emergency Support Team (MEST); Functions of nuclear emergency coordination center. Crisis communication and the planning process; Case studies in crisis management, Establishing emergency management and operations, Identifying, notifying and activating urgent protective action, Providing information to administration, media and issuing instructions and warnings to the public, Assessment of the initial phase, Protecting public and emergency workers, Managing the medical response, countermeasures against agriculture and ingestion, Longer term protective actions, Mitigating the non-radiological consequences, Conducting recovery operations, Other radiological hazards and their mitigation.

References:

1. Gianni Petrangeli, Nuclear Safety, Elsevier Butterworth-Heinemann, 2006.
2. David Mosey, Reactor Accidents: Institutional Failure in the Nuclear Industry, Nuclear Engineering International Special Publication, Wilmington House, UK. 2006
3. Emergency Management, Jeffrey B. Burngarner, ABC-CLIO, Inc, 2008
4. Emergency Incident Management Systems: Fundamentals and Applications. Hoboken, NJ: Wiley and sons, 2006
5. Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency, IAEA updated Tecdoc-953,2003
6. Preparedness and response for a nuclear or radiological emergency safety requirements, IAEA Safety standards series No. GS-R-2, 2002

NE-528: NUCLEAR PROLIFERATION AND SAFEGUARDS

Nuclear power and associated industry; Nuclear power and status of some developed and developing countries; Types of nuclear weapons and their effects; Nuclear weapons proliferation; Nuclear strategic doctrines; Global security and nuclear proliferation; Nuclear arms control and disarmament; Nuclear terrorism; Transfer of nuclear technology and role of exporting countries; IAEA and nuclear safeguards.

References:

1. Fry, M.P., P. Keatinge and J. Rotblat (Eds.): Nuclear Nonproliferation and the Nonproliferation Treaty, Springer-Verlag, 1990.

2. SIPRI: World Armaments and Disarmament, Oxford University Press,1993. 16
3. Singh, N. and E.Mc Whinney: Nuclear Weapons and Contemporary International Law, Martinus Nijhoff, 1989.
4. Leventhal, P. and Y. Alexander (Eds.): Preventing Nuclear Terrorism, Lexington Books, 1987.
5. Glasstone, S. and P.J. Dolan: The Effects of Nuclear Weapons, US DOP and AEC, 1977.
6. London, J. and G.F. White: The Environmental Effects of Nuclear War, Westview Press, 1984.

NE-644: NUCLEAR MATERIAL ACCOUNTANCY & CONTROL

Nuclear material accountancy and control (NMAC); National and international objectives; Authority and responsibilities; Ensuring compliance; Licensing; inspections; National nuclear material accountancy system; Responsibilities; Nuclear material accountancy (measures to maintain knowledge of quantities and locations); Material control (access control, containment and surveillance, seals, monitoring, etc.); Records verification (nuclear material (NM) listing, NM transfers, inventory data, production and shipper/receiver data, etc.); State system of accounting for and control of the nuclear material (SSAC) information system; Type of facilities; location outside facilities (LOFs); nuclear related sites; Facility accounting system; Book inventory; physical inventory; material balance area; Nuclear material inventory verification at different types of nuclear facilities; Material unaccounted for (MUF); NM production; Shipper/receiver difference; NM loss and gain; Material balance evaluation; Cumulative MUF; International nuclear safeguards verification systems.

References

1. Nuclear Verification and Security of Material, Physical Protection Objectives and Fundamental Principles, GOV/2001/41, IAEA, Vienna (2001).
2. IAEA Safeguards: Guidelines for States' Systems of Accounting for and Control of Nuclear Materials,(1980).
3. The Physical Protection of Nuclear Material & Nuclear Facilities, INFCIRC/225/Rev.4, IAEA, Vienna (1999).
4. IAEA, Safeguards Information Series No. 4, (1983), Series No. 2 (1998), Verification Series No. 1&3, (2003), Services Series No. 15 (2008) and IAEA INFCIRC/540,(1997) and IAEA Safeguards System (1965), as Provisionally Extended in 1966 and 1969), INFCIRC/66/Rev. 2, (1968).

NE-645: NUCLEAR FORENSICS & THEIR ATTRIBUTIONS

Physical basis for nuclear forensic science; Nuclear and other radioactive material; Effects of production and treatment of nuclear and other radioactive material on specific signatures (physical, chemical and isotopic signatures); Techniques for forensic signatures; Collateral forensic indicators; Incident response; Securing the incident site; Sample Collection; Interdicted

radiological material in transit; Sample handling; Nuclear forensic laboratory sampling and distribution; Nuclear forensic laboratory; Forensic management team; Sampling in the nuclear forensics laboratory; Nuclear forensic analysis; Characterization goals; Sequence of analysis techniques and methods; Traditional forensic (fingerprints, fibers); Mass spectrometry; Elemental/chemical analysis techniques; Nuclear forensic signatures and attribution process.

References:

1. Kenton J. Moody, Ian D. Hutcheon, and Patrick M. Grant, Nuclear Forensics Analysis, Taylor &Francis publishers, New York, 2005.
2. IAEA, Categorization of Radioactive Sources, IAEA Safety Standards Series No. RS-G-1.9, IAEA, Vienna (2005).
3. IAEA, Combating Illicit Trafficking in Nuclear & other Radioactive Material, Nuclear Security Series No. 6, (2007).
4. IAEA, Identification of Radioactive Sources and Devices, IAEA Nuclear Security Series No. 5, IAEA, Vienna (2007).
5. IAEA, Nuclear Forensics Support, IAEA Nuclear Security Series No. 2, Vienna (2006).
6. IAEA, Security of Radioactive Sources, IAEA Nuclear Security Series No. 11, IAEA, Vienna (2009).

NE-XXX: OPTIONAL COURSES

(ANY APPROVED DNE COURSE MAY BE TAKEN)

NE-696: PROJECT WORK

The 15 credit hours MS Radiation Physics project will focus on the practical experience/exposure in radiation protection at nuclear Power Plants. In this project, the students will perform introductory and theoretical part of the project in fourth semester by registering in three credit hour project work .In fifth semester student has to register in twelve credit hours that are dedicated to placement of student in various PAEC such as Applied Health Physics, Environmental Monitoring, Radiation Emergency Planning, In vitro and in vivo Monitoring, Radioactive Waste Handling, Nuclear Criticality control, Area classification of Power plants, Radiation detection systems, emergency preparedness plans, dispersion modeling and other similar areas of Health Physics and Radiation Protection..