

Detail Syllabi

Course Code:	NS 3130		
Course Name:	Radioisotope Production		
Credit Value:	02		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>This course is designed to provide knowledge to select the best radioisotope production technique for the relevant application and contribute to the nation in future radioisotope production facilities.</p> <p>At the end of this course the students will be able to</p> <ul style="list-style-type: none"> • evaluate the best radioisotope production technique for their future research in nuclear science or application in the industry. • describe unique features of the production facilities in the world. • apply the theory in a real life scenario such as a future medical radioisotope production facility in Sr Lanka. 			
<p>Course Content: (Main topics, Sub topics)</p> <p>Introduction to radioisotope production: Nuclear chart and key regions, Uses of radioisotopes in study properties of nuclear structure, study origin of the elements and astrophysical processes, tests of fundamental symmetries and Societal applications and benefits, Present status of radioisotope production (nuclear science, medicine, industry), Basic principles of nuclear reactions: Reaction types and nomenclature, Coulomb barrier, Q value, Nuclear reaction cross-section, Saturation factor; Radioisotope production mechanisms: Long lived radioisotopes using Reactor based production Neutron sources, Exotic radioisotopes via Fragmentation, Fission and Fusion, Instrumentation: Nuclear reactors, Neutron sources, Electrostatics accelerators (Cockcroft-Walton, Van de Graaff accelerators), Cyclotrons, Synchrotrons and Rings, Linear accelerators, Main parameters effect on radioisotopes production (Top energy, Particle range, Intensity, Beam power and Beam emittance), Radioisotope separation methods: ISOL method (HRIBF, ISAC, SPIRAL,</p>			

ISOLDE, SPES, EURIOSOL), In-flight method (NSCL, FRIB, RIKEN, GANIL, ANL, RIBBAS), Chemical separation, Pros and Cons of separation techniques, Synthesis of Transuranium Elements: Neutron-induced reactions (Z=93, 95, 99, 100), light-charged particle-induced (Z=94, 96-98, 101), Hot fusion reactions (Z=102-106), Cold fusion reactions (Z=107-113), Superheavy elements, Regulations on radioisotope production (Sri Lanka Atomic Energy Regulatory Council Act No. 40 of 2014, refer to AEB)			
Teaching /Learning Methods: Lectures, discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 30 %		Final Assessment 70 %	
Details: quizzes %, mid-term %, other % (specify) Mini project 20% Simulation software 10%		Theory (%) 70 %	Practical (%) Other (%) (specify)
Recommended Reading: <ul style="list-style-type: none"> Choppin, G. Liljenzin, J.O. Rydberg, J. Radiochemistry & Nuclear Chemistry, 2002, 3rd Ed. Butterworth Heinemann USA Stevenson, N.R. Isotopes Production and Applications of 21st Century Proceedings of the 3rd international conference on isotopes, 2000, World Scientific Publishing Co Pte Ltd. 			

Course Code:	NS 3033		
Course Name:	Nuclear Structure and Nuclear Reactions		
Credit Value:	2		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning

	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>At the end of this course the students will be able to</p> <ul style="list-style-type: none"> • Explain different nuclear models • Discuss the nuclear structure properties based on nuclear models • Discuss how nuclear models can be use to predict low energy level structures and radioactive decay. • Explain nuclear reaction types • Discuss the nuclear experimental measurements based on different nuclear reactions 			
<p>Course Content: (Main topics, Sub topics)</p> <p>History of nucleus; nuclear properties; chart of nuclides; nuclear model introduction; Liquid drop model: semi-empirical mass formula, nuclear property relationships; fission model: mass distribution, energy and structure properties; Shell model: nucleon Hamiltonian, nucleon-nucleon potentials, energy levels and magic numbers, spin-orbit interaction, spin and parity, ground and excited state nuclear structure for simple nucleus; Collective model; rotation and vibration models: properties, nuclear databases and information</p> <p>Introduction to experiments for nuclear structure; nuclear reaction types; conservation laws. Importance of nuclear reactions: structure probe, production and astro studies; energetics of nuclear reactions, isospin, lab and CM frames; reaction cross sections and experimental measurements; Coulomb scattering, nuclear scattering, scattering cross sections, introduction to optical model; compound nuclear reactions, direct nuclear reactions, resonance reaction, heavy-ion reactions</p>			
<p>Teaching /Learning Methods:</p> <p>Lectures and discussions</p>			
<p>Assessment Strategy: Continuous assessment and final assessment</p>			
<p>Continuous Assessment</p> <p>30 %</p>	<p>Final Assessment</p> <p>70 %</p>		
<p>Details: quizzes %, mid-term %, other % (specify)</p>	<p>Theory (%)</p>	<p>Practical (%)</p>	<p>Other (%) (specify)</p>

Mini project 25 %	70 %		
In-class assignments 5 %			
Recommended Reading:			
<ul style="list-style-type: none"> "Introductory Nuclear Physics", 1988 K.S. Krane, John Wiley and Sons 			

Course Code:	NS 3034		
Course Name:	Nuclear Power and Fuel Cycle		
Credit Value:	2		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	30		70

Course Aim/Intended Learning Outcomes:

At the completion of this course students will be able to

- develop an understanding of the basic principles of nuclear power generation.
- develop an understanding of how nuclear energy is used to generate electrical power in different types of power plants.
- illustrate the process of nuclear energy production in nuclear reactors, including planning, operation, control as well as the radiation waste management.
- evaluate the pros and cons of use of nuclear power compared to other energy sources

Course Content: (Main topics, Sub topics)

Methods of production of nuclear energy, Different types of nuclear reactors : Isotope batteries, fusion reactors, nuclear reactors; structural components of nuclear power plant system; Types of nuclear reactors; nuclear power generation process in nuclear reactors, operating conditions, neutron irradiation; Recycling of nuclear fuel; Advantages of nuclear

power compared to other energy sources. Nuclear weapon production and non-proliferation issues; Environmental, economic and political Issues on nuclear power plant generation; Nuclear waste management			
Teaching /Learning Methods:			
Direct lectures, In-class and take-home assignments, tutorial classes			
Assessment Strategy:			
Continuous Assessment		Final Assessment	
30%		70%	
Details:	Theory (%)	Practical (%)	Other (%) (specify)
Inclass assignments 30	607 70		
Recommended Reading:			
<ul style="list-style-type: none"> • Dr. Prinath Dias, "An Introduction to Nuclear Technology", ISBN : 978-955-54544-0-7 • John R. Lamarsh, "Introduction to Nuclear Engineering", Addison Wesley Publishing Company • John R. Lamarsh, "Introduction to Nuclear Reactor Theory", Addison Wesley Publishing Company • J.J. Duderstadt and L.J. Hamilton, "Nuclear Reactor Analysis", John Wiley and Sons, Inc. 			

Course Code:	NS 3035
Course Name:	Nuclear Astrophysics
Credit Value:	02
Core/Optional	Core

Hourly Breakdown	Theory	Practical	Independent Learning
	30 hrs		70 hrs

Course Aim/Intended Learning Outcomes:

The course aims to provide students with a sufficiently broad picture of how the methods and concepts of two of the most fascinating scientific fields, Astrophysics and Nuclear Physics are combined and applied together. The course builds upon the fundamentals of astrophysics and cosmology and introduces advanced concepts from nuclear physics, offering a deeper understanding of how nuclear processes govern astrophysical phenomena.

At the end of this course the students will be able to;

- Understand demonstrate a proficiency in the fundamental concepts in astrophysics and cosmology (Theory and Observations).
- Explain the underlying physics behind the formation of stars and stellar evolution, including

its computational modelling.

- Analyze key processes such as thermonuclear reactions, nucleosynthesis paths, and nuclear

burning stages in stars.

- Apply basic numerical modeling techniques to simulate astrophysical nuclear processes.
- Develop skills in scientific communication, including delivering effective presentations and

writing scientific papers.

Course Content: (Main topics, Sub topics)

Astrophysics: Introduction to high-energy astrophysics (theory and observation), Hertzsprung ~ Russell diagram, Internal structure of stars, Equations of state, Energy transport mechanisms in stars, Stellar evolution of single stars, Nuclear reactions in stellar cores.

Cosmology: Fundamental observations of the Universe, The concordance model of cosmology,

<p>Structure and homogeneity of the Universe, The hot early Universe, Deuterium bottleneck, Primordial helium synthesis.</p> <p>Nuclear Physics: Nuclear mass and binding energy, Nomenclature of nuclear reactions, The nuclear shell model, Branching ratios and mixing ratios, γ-ray transitions in stellar plasmas, Weak interactions in astrophysical environments, β-decay probabilities and decay modes, β-decays in stellar plasmas, Nuclear Astrophysics Experiments (STELLA).</p> <p>Capstone and Applications: Interpretation of astrophysical data and imagery, Nuclear Astrophysics meets python (Labs), Techniques for summarizing research papers, Case studies from current research in nuclear astrophysics.</p>			
<p>Teaching /Learning Methods:</p> <p>Lectures and discussions</p>			
<p>Assessment Strategy: Continuous assessment and final assessment</p>			
<p>Continuous Assessment</p> <p>55 %</p>		<p>Final Assessment</p> <p>45 %</p>	
<p>Details: quizzes %, mid-term %, other % (specify)</p> <p>Attendance/participation 5</p> <p>Assignment and coding lab 10</p> <p>Group project 40</p>		<p>Theory (%)</p> <p>45</p>	<p>Practical (%)</p> <p>Other (%) (specify)</p>
<p>Recommended Reading:</p> <ul style="list-style-type: none"> • C. Iliadis, Nuclear Physics of Stars, Wiley-VCH Verlag GmbH Co., 2007. • D.D. Clayton, Principles of Stellar Evolution and Nucleosynthesis, The University of Chicago Press, 1983 			

Course Code:	NS 3036
Course Name:	Radiological Facility Management
Credit Value:	02

Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>The main aim of this course is to gain knowledge and skills on managing radiological sources, equipment and facility in an effective and safe manner.</p> <p>At the end of this course the students will be able to</p> <ul style="list-style-type: none"> • Explain the regulatory framework governing different radiological facilities and how to maintain compliance with national/ international standards • Discuss effective radiation protection methods that needs to implement in a radiological facility • Discuss how to manage radiological sources, equipment and waste in a radiological facility • Explain a key features of emergency preparedness program in a facility 			
<p>Course Content: (Main topics, Sub topics)</p> <p>Types of radiological facilities: medical, industrial, education and research institutes; roles and responsibilities of facility manager, overview of IAEA standards; Regulatory framework and licensing : licensing and source authorization, record keeping and reporting procedures compliance to national and IAEA standards; Facility design and shielding: principles of safety facility design, controlled vs supervised area, access control and zoning signage based on radiation dose calculations and ALARA principle; protective clothing and barriers; personal dosimetry and area monitoring procedures and reporting; Equipment and source management: procurement, commissioning, acceptance testing, sealed vs unsealed sources, inventory control; leak testing, decommissioning procedures; QA/QC : QA/QC in imaging and therapy equipment, calibration and preventive maintenance, performance evaluation documentation; Radioactive waste management: waste classification; segregation and storage; disposal methods; transport regulations; Emergency preparedness and responses procedures; Administrative and human resource (HR) management : staffing, staff training programs, SOPs and documentations; budgeting, resource allocations; internal audits, inspection and continuous improvements, best practices</p>			
<p>Teaching /Learning Methods:</p>			

Lectures and discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 30 %	Final Assessment 70 %		
Details: quizzes %, mid-term %, other % (specify) Case studies 30	Theory (%) 70	Practical (%)	Other (%) (specify)
Recommended Reading: <ul style="list-style-type: none"> IAEA Safety Standards Series: General Safety Requirements Part 3 – Radiation Protection and Safety of Radiation Sources ICRP Publication 103 – The 2007 Recommendations of the International Commission on Radiological Protection NCRP Reports on facility shielding and protection 			

Course Code:	NS 3037		
Course Name:	Nuclear Spectroscopy		
Credit Value:	02		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	15 hrs	30 hrs	55 hrs
Course Aim/Intended Learning Outcomes: At the end of this course the students will be able to <ul style="list-style-type: none"> Explain different spectroscopy methods, measurements and analysis Apply nuclear spectroscopy in sample analysis, studies of nuclear properties and research 			

Course Content: (Main topics, Sub topics)

Detector measurement modes; destructive and non-destructive analytical methods : UV spectroscopy, Atomic Absorption spectroscopy, High performance liquid chromatography, IR and Raman spectroscopy; Radiation/particle counting and monitoring: time of flight (TOF), calorimetry; Micro Channel Plates (MCP), current measurements, alpha spectroscopy, beta spectroscopy, liquid scintillation counting; spectrum shapes with decay types; gamma spectroscopy : sodium iodide, high purity Ge detector; tracking; in-situ gamma spectroscopy, neutron activation analysis; introduction to Geant simulations; mass spectroscopy; X ray fluorescence spectroscopy; nuclear resonance fluorescence and Mossbauer spectroscopy; laser spectroscopy for nuclear science, recently developed nuclear spectrometers

Teaching /Learning Methods:

Lectures and discussions

Assessment Strategy: Continuous assessment and final assessment

Continuous Assessment	Final Assessment		
30 %	70 %		
Details: quizzes %, mid-term %, other % (specify)	Theory (%)	Practical (%)	Other (%) (specify)
Assignments 10%	70 %		
Mini project 20%			

Recommended Reading:

- Alpha, Beta Gamma Ray Spectroscopy, 2012, K. Siegbahn, Elsevier
- Methods in Physical Chemistry, Rolf Schäfer, Peter C. Schmidt, [ISBN 9783527327454](#), Online [ISBN 9783527636839](#), [doi:10.1002/9783527636839](#)
- Gilmore, *Practical Gamma-Ray Spectrometry* (2nd ed.,) 2008, Wiley.
- Glascock, Michael (2013) "[Nuclear Spectroscopy](#)". *Treatise on Geochemistry*. pp. 273–290. [doi:10.1016/B978-0-08-095975-7.01419-4](#)
- Nuclear condensed matter physics, Günter Schatz and Alois Weidinger, [ISBN 978-0471954798](#)

Course Code:	NS 3038		
Course Name:	Radiation effects on Plant Systems		
Credit Value:	02		
Core/Optional	Optional		
Hourly Breakdown	Theory	Practical	Independent Learning
	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>At the end of this course the students will be able to;</p> <ul style="list-style-type: none"> describe the types of radiation and their fundamental interactions with biological matter that initiate cellular responses. detail the mechanisms of radiation-induced molecular damage (especially DNA) and the complex cellular pathways involved in damage recognition, repair, and programmed cell death. analyze animal tissue responses to radiation discuss the specific and unique effects of radiation on plant physiology, growth, development, reproduction, and genetic stability, from the cellular to the whole-plant level. compare and contrast the general principles and specific mechanisms of radiation response, sensitivity, and resilience observed in animal tissues versus plant systems. 			
<p>Course Content: (Main topics, Sub topics)</p> <p>Cellular & Molecular Basis of Radiation Response: DNA damage in human tissues and plant genomes; DNA Repair Pathways; Cell Cycle and Radiosensitivity; Cellular Fate; The Oxygen Effect, Linear Energy Transfer (LET), and Dose Rate effects on cellular survival; Plant Radiosensitivity & Growth Responses: Factors Influencing Plant Radiosensitivity; Effects on Seed Germination & Seedling Vigor; Impact on Vegetative Growth; Abnormal Morphology & Developmental Abnormalities; Physiological Impacts; Genetic Effects in Plants: Detailed analysis of chromosomal aberrations, gene mutations, and translocations; Heritable Changes: Impact of radiation-induced genetic changes on plant populations and their implications for plant breeding; Reproductive Biology: In-depth study of radiation's impact on pollen viability, fertilization success, seed set, embryo development, and offspring viability across generations; Plant Stress Response Pathways: Detailed exploration of antioxidant defense systems, heat shock proteins, phytohormone regulation in irradiated plants; Case Studies: Advanced analysis</p>			

of plant responses in contaminated environments and their ecological recovery patterns, focusing on genetic and reproductive aspects.			
Teaching /Learning Methods: Lectures and discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 40 %		Final Assessment 60 %	
Details: quizzes %, mid-term %, other % (specify) Assignment 20 Presentation 20	Theory (%) 60	Practical (%)	Other (%) (specify)
Recommended Reading: <ul style="list-style-type: none"> • Hall E. J. (2018), Radiobiology for Radiologists • Reports from international bodies (e.g., UNSCEAR, IAEA) on biological effects of radiation • A curated collection of peer-reviewed scientific articles and reviews focusing on radiation effects in various biological systems (provided by the lecturer in charge) 			

Course Code:	NS 3039		
Course Name:	Technology in Nuclear Science I		
Credit Value:	02		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning

	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>The course aims to provide students with a sufficiently broad picture of how nuclear science use in advance nuclear technology facilities</p> <p>At the end of this course the students will be able to;</p> <ul style="list-style-type: none"> Explain how nuclear science and technology can be applied in different experiments and facilities 			
<p>Course Content: (Main topics, Sub topics)</p> <p>Introduction to nuclear experiments; Instrumentations for nuclear and non-nuclear science experiments : instrumental analysis and different analytical techniques; Accelerator types : medical accelerators : cyclotrons; introduction to accelerator physics, beam physics, nuclear engineering and reactor physics. Introduction to advanced nuclear experiments and technology; Nuclear technology in different fields : agriculture, hydrology and medicine.</p>			
<p>Teaching /Learning Methods:</p> <p>Lectures and discussions</p>			
<p>Assessment Strategy: Continuous assessment and final assessment</p>			
<p>Continuous Assessment</p> <p>30 %</p>		<p>Final Assessment</p> <p>70 %</p>	
<p>Details: quizzes %, mid-term %, other % (specify)</p> <p>In-class assignments 30</p>	<p>Theory (%)</p> <p>70</p>	<p>Practical (%)</p>	<p>Other (%) (specify)</p>
<p>Recommended Reading:</p> <ul style="list-style-type: none"> Wiedemann, Helmut – <i>Particle Accelerator Physics</i>. 4th ed. Springer, 2015. Wille, Klaus – <i>The Physics of Particle Accelerators: An Introduction</i>. Oxford University Press, 2000 Wangler, Thomas P. – <i>RF Linear Accelerators</i>. 2nd ed. Wiley-VCH, 2008. https://www.ortec-online.com/resources/application-notes 			

- <https://home.cern/science/accelerators>
- <https://www.lanl.gov/science/>

Course Code:	NS 4036		
Course Name:	Radiopharmaceuticals		
Credit Value:	03		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	45 hrs		105 hrs
Course Aim/Intended Learning Outcomes:			
At the end of this course the students will be able to			
<ul style="list-style-type: none"> • define what are radiopharmaceuticals • explain production methods of short lived radioisotopes useful in radiopharmaceuticals • explain synthesis methods and labelling methods used in radiopharmaceutical production • discuss the quality control of radiopharmaceuticals • explain applications of radiopharmaceutics 			
Course Content: (Main topics, Sub topics)			
Introduction to pharmaceutics in general; introduction to radiopharmaceuticals and their importance; radioisotopes in nuclear medicine; Introduction to imaging instrumentations; Small molecule radiotracers in diagnostics radiopharmaceuticals; Radiopharmaceutical with theranostic effect; radiolabelling methods to produce radiopharmaceuticals in imaging and therapeutic; Production of short lived radioisotopes for imaging (PET, SPECT) and therapeutic; Synthesis methods of radiopharmaceuticals E.g. labelling with Lu-177, I-131, N-13, O-15, C-11,F-18, Ga-68, Tc-99m. Automated synthesis modules of radiopharmaceutical production; Quality control; Applications of radiopharmaceuticals in oncology, neurological applications, cardiac and pediatric applications			

Teaching /Learning Methods: Lectures and discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 30 %	Final Assessment 70 %		
Details: quizzes %, mid-term %, other % (specify) Assignment 20 Presentation 10	Theory (%) 70	Practical (%)	Other (%) (specify)
Recommended Reading: <ul style="list-style-type: none"> • [Kilbourn, M., & Scott, P. (2021). <i>Handbook of Radiopharmaceuticals</i> (2nd ed.). Wiley. ISBN:9781119500575 DOI:10.1002/9781119500575 • Welch, M.J. Redvanly, C.S.(2003). <i>Handbook of Radiopharmaceuticals: Radiochemistry and Applications</i>. Wiley. ISBN: 0471495603, 9780471495604 			

Course Code:	NS 4037		
Course Name:	Technology in Nuclear Science II		
Credit Value:	03		
Core/Optional	Optional		
Hourly Breakdown	Theory	Practical	Independent Learning
	45 hrs		105 hrs
Course Aim/Intended Learning Outcomes:			

The course aims to provide the knowledge to use nuclear science and technology in designing advanced facilities and applications

At the end of this course the students will be able to

- Discuss the applications of various technology associated with nuclear science such as vacuum systems, RF systems and magnetism

Course Content: (Main topics, Sub topics)

Vacuum technology : importance in nuclear science, high pressure systems; gas theories, gas-flow formalities and mechanisms; basic calculations in vacuum systems; types of vacuum pumps, mechanism of vacuum pumps; design of vacuum pumps; Qualitative description of pumping process: flow calculations, pressure gauges

RF systems in nuclear facilities : RF wave production

Magnetism and magnets in nuclear science :charge particle manipulation for experiments, Magnetic resonance imaging (MRI), mass spectroscopic applications; applications of magnetic and electrostatic fields in beam physics

Trajectories of charge particles in electric fields: introduction to SIMION simulation software.

Teaching /Learning Methods:

Lectures and discussions

Assessment Strategy: Continuous assessment and final assessment

Continuous Assessment 30 %	Final Assessment 70 %		
Details: quizzes %, mid-term %, other % (specify)	Theory (%)	Practical (%)	Other (%) (specify)
Quizzes 20 Case study 10	70		

Recommended Reading:

- O'Hanlon, J. F. – *A User's Guide to Vacuum Technology* (4th ed.,) 2020 Wiley.
- Hablanian, M. H. – *High-Vacuum Technology: A Practical Guide* 1997 CRC Press.

- Roth, A. – *Vacuum Technology* (3rd ed.,) 1990 Elsevier
- Wangler, T. P. – *RF Linear Accelerators* (2nd ed.,) 2008 Wiley-VCH
- Cullity, B. D., & Graham, C. D. – *Introduction to Magnetic Materials* (2nd ed.,) 2009 Wiley-IEEE Press
- <https://simion.com/docs/>

Course Code:	NS 4038		
Course Name:	Radiation effects on material		
Credit Value:	03		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	45 hrs		105 hrs
Course Aim/Intended Learning Outcomes:			
At the end of this course the students will be able to			
<ul style="list-style-type: none"> • Describe different scopes of radiation interactions with matters in industry and analytical applications. • Discuss radiation induced chemical processing in material developments, nuclear power and nuclear waste management • Discuss the role of non-destructive testing methods and their applications in industry • Discuss the applications of different X ray techniques in sample analysis and medical imaging applications 			
Course Content: (Main topics, Sub topics)			
<p>Introduction Radiation types and sources; Radiation interactions with matter; dosimetry and its use of dose monitoring: chemical dosimeters: Fricke dosimeter, ceric-cerous dosimeter; chemical changes of matter with radiation: radiolysis, radical and ion formation</p> <p>Radiation induced chemical processing : Radiation chemistry in aqueous solutions: water radiolysis; G values; Radiation chemistry application in nuclear power plant operation and nuclear waste management; Radiation effects in polymer degradation and modifications:</p>			

grafting, cross linking and polymer degradation; production of inorganic material : silicon carbide fiber; Radiation treatment in environmental purification process : sewage sludge, water purification; flue gas purification etc.

Non destructive testing : NDT methods : Magnetic Particle testing (MT), Liquid Penetrant Testing (PT), Eddy current testing (ET), Radiographic testing (RT) and Ultrasonic Testing (UT). Techniques and applications in industry.

X ray techniques in analysis : Introduction to X ray techniques, properties of X rays; safety measures; X ray interactions with matter; attenuation, scattering, absorption; X ray scattering in small angles, X ray spectroscopic techniques; X ray fluorescence spectroscopy, X ray photoelectron spectroscopy, X ray absorption spectroscopy: near edge and X ray absorption fine structure spectroscopy; X ray diffraction spectroscopy; X ray imaging techniques for radiography: X ray computed tomography, X ray crystallography; case studies

Teaching /Learning Methods:

Lectures and discussions

Assessment Strategy: Continuous assessment and final assessment

Continuous Assessment 30 %	Final Assessment 70 %		
Details: quizzes %, mid-term %, other % (specify) In class assignments 30	Theory (%) 70	Practical (%)	Other (%) (specify)

Recommended Reading:

- Radiation Applications : Tamada, M. (2018).
- Radiation Processing of Polymers and Its Applications. In: Kudo, H. (eds) Radiation Applications. An Advanced Course in Nuclear Engineering, vol 07. Springer, Singapore. https://doi.org/10.1007/978-981-10-7350-2_8
- Practical Non Destructive Testing Baldev Raj, T. Jayakumar, M. Thavasimuthu, Woodhead Publishing Ltd 2nd Ed. ISBN 1-85573-600-4

- X-Ray Techniques in Analytical Chemistry 2024 Masime, J.O. Ndangili, P. M. Lalah, J. O.

DOI: 10.5772/intechopen.1008735

Course Code:	NS 4039		
Course Name:	Cancer Biology and Radiation Therapy		
Credit Value:	03		
Core/Optional	Optional		
Hourly Breakdown	Theory	Practical	Independent Learning
	45 hrs		105 hrs

Course Aim/Intended Learning Outcomes:

At the end of this course the students will be able to;

- describe the molecular and cellular hallmarks of cancer
- explain how radiation damages cancer cells
- discuss the principles and applications of different radiation therapy modalities
- discuss the rationale and biological basis for combining radiation therapy with other cancer treatments
- assess the general principles of managing radiation-induced side effects and the importance of quality assurance in radiation oncology

Course Content: (Main topics, Sub topics)

Introduction to Cancer Biology: Cancer definitions, epidemiology, and global burden, Hallmarks of Cancer (Sustaining proliferative signaling, evading growth suppressors, resisting cell death, enabling replicative immortality, inducing angiogenesis, activating invasion and metastasis), Molecular Basis of Cancer, Carcinogenesis: Chemical, physical (including radiation), and viral carcinogenesis, Cancer Genetics and Epigenetics, Cancer Diagnosis; Fundamentals of Radiation Interaction with Tissue: Types of Ionizing Radiation in Therapy, Radiation Sources and Production, Interaction of Radiation with Matter, Radiation Units and Dosimetry, Basic Principles of Radiation Protection (relevant to patient and staff safety); Cellular and Molecular Radiobiology of Cancer: Radiation-Induced DNA Damage, DNA Repair Mechanisms, Cellular Responses to Radiation, Tumor Radiosensitivity and

Radioresistance, The 4 R's of Radiobiology, Dose-Response Curves; Normal Tissue Response to Radiation: Acute vs. Late Effects, Tissue Radiosensitivity, Therapeutic Ratio, Specific Organ System Responses: Skin, Gastrointestinal Tract, Hematopoietic System, Lung, Heart, Brain/Spinal Cord, Kidney, Liver, Reproductive Organs; Principles and Techniques of Radiation Therapy: External Beam Radiation Therapy (EBRT), Brachytherapy, Systemic Radiation Therapy, Treatment Planning, Fractionation and Protraction; Combined Modalities and Future Directions: Radiation with Surgery, Radiation with Chemotherapy, Radiation with Immunotherapy, Management of Radiation Side Effects, Quality Assurance in Radiation Oncology, Emerging Concepts			
Teaching /Learning Methods: Lectures and discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 40 %		Final Assessment 60 %	
Details: quizzes %, mid-term %, other % (specify) Assignment 20 Presentation 20	Theory (%) 60	Practical (%)	Other (%) (specify)
Recommended Reading: <ul style="list-style-type: none"> Hall, Eric J., and Giaccia, Amato J. <i>Radiobiology for the Radiologist</i>. [Latest Edition]. Lippincott Williams & Wilkins. (Focus on chapters relevant to cancer and therapy) Reports from professional organizations (e.g., ASTRO, ESTRO) Peer-reviewed scientific articles and clinical guidelines 			

Course Code:	NS 4040
Course Name:	Isotopes in Environmental Studies
Credit Value:	02
Core/Optional	Optional

Hourly Breakdown	Theory	Practical	Independent Learning
	30 hrs		70 hrs
<p>Course Aim/Intended Learning Outcomes:</p> <p>At the end of this course the students will be able to</p> <ul style="list-style-type: none"> • identify stable and radioactive isotopes useful in ecological studies • explain the advantages of using isotopes in environmental studies • explain how the isotopic properties can be useful in studying isotope geochemistry • discuss different case studies of isotopes use in environmental studies 			
<p>Course Content: (Main topics, Sub topics)</p> <p>Stable and radioactive isotopes useful in ecological studies; Benefits of isotopic studies in environmental studies and current issues such as climate change, loss of biodiversity, pollution monitoring and mitigation strategies etc.; Isotope geochemistry: isotope fractionation, decay rates of radioisotopes apply in dating; radioisotopes studies : environmental risk assessments : Eg ^{226}Ra in ground water; radon levels to assess indoor exposure; tritium for water resource management; Assessing contaminants, e.g assessing ^{137}Cs contaminants in soil erosion studies; Tracer studies : E.g. Be-7 and Be-10 in atmosphere; lithium and radium isotopes in marine environment etc. ; stable isotope studies : carbon cycle, oxygen isotopes in hydrology; nitrogen isotopes in agriculture applications, study of isotopic signatures in food sources</p>			
<p>Teaching /Learning Methods:</p> <p>Lectures and discussions</p>			
<p>Assessment Strategy: Continuous assessment and final assessment</p>			
Continuous Assessment		Final Assessment	
30 %		70 %	
Details: quizzes %, mid-term %, other % (specify)	Theory (%)	Practical (%)	Other (%) (specify)
Assignment 20			
Presentation 10	70		

Recommended Reading:

- Baskaran M. (2012) ,Handbook of Environmental Isotope Geochemistry, Springer Berlin, Heidelberg. DOI <https://doi.org/10.1007/978-3-642-10637-8>
- Walther,C. Gupta, D.K. (2015) Radionuclides in the Environment, Springer Cham. DOI <https://doi.org/10.1007/978-3-319-22171-7>
- <https://www.solubilityofthings.com/applications-isotopes-environmental-science>

Course Code:	NS 4041		
Course Name:	Nanomaterials in Radiological Applications		
Credit Value:	03		
Core/Optional	Core		
Hourly Breakdown	Theory	Practical	Independent Learning
	45 hrs		105 hrs
Course Aim/Intended Learning Outcomes:			
At the end of this course the students will be able to			
<ul style="list-style-type: none">• identify nanomaterials• Discuss the benefits of nanomaterial in nuclear medicine and radiological applications• Explain the latest advancements of nanotechnology in diagnostic and therapeutic radiology and opportunities in nuclear medicine			
Course Content: (Main topics, Sub topics)			
Introduction to nanotechnology and nano material; general properties of nano material; nano materials in medicine; nano material devices for medical imaging: nanoparticles based contrasting agents for Magnetic Resonance Imaging (MRI), Ultra Sound, Computed Tomography (CT), PET, SPECT etc.; nanotechnology applications in radiotherapy: mechanisms and advantages; nano particles with photodynamic therapy (PDT) by generating reactive oxygen species; nano material probes in theranostic and nuclear imaging tools. Limitations of nanomaterial in nuclear medicine.			

Teaching /Learning Methods:			
Lectures and discussions			
Assessment Strategy: Continuous assessment and final assessment			
Continuous Assessment 30 %	Final Assessment 70 %		
Details: quizzes %, mid-term %, other % (specify)	Theory (%)	Practical (%)	Other (%) (specify)
In-class assignments 30	70		
Recommended Reading:			
<ul style="list-style-type: none"> Paata J. Kervalishvili, Panayotis H. Yannakopoulos (Ed), (2016) Nuclear Radiation Nanosensors and Nanosensory Systems, Springer Dordrecht https://doi.org/10.1007/978-94-017-7468-0 Sghaier, H. (Ed.). (2025). Ionizing Radiation - Insights into Chemistry, Biology, and Applications. IntechOpen. doi: 10.5772/intechopen.1004664 			