

# M.Sc Nuclear Medicine & Molecular Imaging Technology

[Syllabus Approved by Board of Studies, Medical & Health Sciences]

<b>Programme Code</b>	:	HLTH19
<b>Programme Details</b>	:	M.SC NUCLEAR MEDICINE & MOLECULAR IMAGING TECHNOLOGY
<b>Programme Learning Outcomes (PLOs / PSOs)</b>	:	ANNEXED IN THE BELOW FORMAT.
<b>Eligibility Criteria</b>	:	<p>ONLY INDIAN NATIONALS CAN APPLY. GRADUATION WITH MINIMUM 60% MARKS IN AGGREGATE IN ANY OF THE FOLLOWING SUBJECTS. B. SC UNIVERSITY RECOGNISED BY UGC.</p> <ul style="list-style-type: none"> <li>• B. SC IN NUCLEAR MEDICINE <b>OR</b></li> <li>• B. SC IN PHYSICS, CHEMISTRY, MATHEMATICS, ZOOLOGY, BOTANY, MICROBIOLOGY, BIOCHEMISTRY, BIOINFORMATICS, BIOTECHNOLOGY, WITH PHYSICS OR CHEMISTRY AS ONE OF THE SUBJECTS IN B. SC.</li> </ul>
<b>Duration of the Course</b>	:	2 YEARS
<b>Programme Structure (Credit-Based)</b>	:	NA
<b>Detailed Course Syllabus</b>	:	ANNEXED IN THE BELOW FORMAT.
<b>Teaching–Learning Methodologies</b>	:	DIDACTIC LECTURES FOLLOWED BY HANDS-ON EXPERIENCE.
<b>Examination &amp; Evaluation System</b>	:	ANNUAL EXAMINATION
<b>Internship / Project / Dissertation Guidelines</b>	:	1 YEAR MANDATORY INTERNSHIP , THESIS SUBMISSION PRIOR TO FINAL EXAMINATION
<b>Program In Charge</b>	:	PROF. VENKATESH RANGARAJAN venkatesh.rangarajan@tmc.gov.in
<b>Annexure (Books / Journals etc)</b>	:	ANNEXUED

# **M.Sc. NUCLEAR MEDICINE & MOLECULAR IMAGING TECHNOLOGY**

*Programme Code:* HLTH19

*Programme Outcome:*

- To be able to understand and apply knowledge of radiation detectors and various imaging and non- imaging equipments like Uptake probe, Gamma Camera, SPECT, PET, Intraoperative Probes in a nuclear medicine laboratory. Role and application of complimentary imaging devices such as USG, CT & MRI.
- To introduce and train on concepts of radionuclide generators and medical cyclotron, radiopharmacy techniques and understand the invivo kinetics of radiopharmaceuticals used in imaging and therapy.
- To understand quality control of instruments and radiopharmaceuticals. To understand and adopt appropriate quality assurance practices in delivery of nuclear medicine services.
- To be able to assume responsibility as Nuclear Medicine Physicist, Radiochemist Radio-pharmacist, NM Technologist, and Radiation Safety Officer.
- Basic knowledge in biology, biochemistry, physics, and mathematics required for nuclear medicine and its applications.
- Knowledge of patho - phycological conditions in nuclear medicine.
- Familiar with hospital ethics and patient care required in nuclear medicine.
- Knowledge of imaging and non-imaging instruments, data collection and analysis for nuclear medicine applications.
- Knowledge on radiochemistry and radiopharmaceuticals for nuclear medicine applications.
- Advanced knowledge on practical aspects of computer hardware and programming required in nuclear medicine.

## DETAILED COURSE STRUCTURE

List of Courses				
Semester	Course Code	Course name	Credits	Marks
1 <sup>st</sup> Semester/1 <sup>st</sup> Year	MNMMI 101	Basic Science in nuclear medicine	80	100
	MNMMI 102	Basic mathematics and computers in nuclear medicine	80	100
	MNMMI 103	Human anatomy, physiology and Patient Care	80	100
	MNMMI 104-P	Basic sciences in nuclear medicine	40	50
	MNMMI 105-P	Computer hardware and programming	40	50
2 <sup>nd</sup> Semester/1 <sup>st</sup> Year	MNMMI 201	Radiation Physics and Biology	80	100
	MNMMI 202	Non-imaging and Imaging Instrumentation in nuclear medicine	80	100
	MNMMI 203	Radio-chemistry and Radio-pharmacy	80	100
	MNMMI 204-P	Radiation biology and Radiation Safety	40	50
	MNMMI 205-P	Radio-chemistry and Radio-pharmacy	40	50
3 <sup>rd</sup> Semester/2 <sup>nd</sup> Year	MNMMI 301	Non Imaging Instrumentation in nuclear medicine	80	100
	MNMMI 302	Advanced instrumentation in Nuclear Medicine & Molecular Imaging	80	100
	MNMMI 303	Clinical Nuclear Medicine	80	100
	MNMMI 304-P	Quality control of non Imaging Equipment		
	MNMMI 305-P	Clinical Nuclear medicine		
4 <sup>th</sup> Semester/2 <sup>nd</sup> Year	MNMMI 401	Advanced Radio-chemistry	80	100
	MNMMI 402	Therapeutic Nuclear Medicine & Radiation Dosimetry	40	50
	MNMMI 403	Project (Elective)	80	100
	MNMMI 405-P	Quality control of Imaging Equipment	40	50
	MNMMI 405-P	Therapeutic Nuclear Medicine & Radiation Dosimetry	40	50
<b>Total</b>			<b>1280</b>	<b>1600</b>

## COURSE COORDINATOR

Course name	Course Coordinator
Basic science in nuclear medicine and Research Methodology	Mr. Ashish Kumar Jha (ashish.kumar.jha.77@gmail.com)
Basic mathematics, statistics and computers in nuclear medicine	
Human anatomy, physiology and Patient Care	
Radiation Physics and Radiation Safety in Nuclear medicine and Cyclotron	
Non-imaging and Imaging Instrumentation in nuclear medicine	
Radio-chemistry, Radio-pharmacy and Basic Clinical Practice	
Advanced Clinical Nuclear Medicine	
Advanced Radio-chemistry and Radio-pharmacy	
Therapeutic Nuclear Medicine & Radiation Dosimetry	
Advanced instrumentation and Technology in Nuclear Medicine	

## DETAILED SYLLABUS

### MNMMI 101-Basic science in nuclear medicine and Research Methodology (80 Hours)

Coordinators: Mr. Ashish Kumar Jha  
ashish.kumar.jha.77@gmail.com

#### Course Details:

- **Basic physics in nuclear medicine**
  - **Atomic structure**  
Fundamental particles of atom, Bohr's model of atom, structure of nucleus, orbit, orbital and quantum number, atomic number, mass number, atomic mass unit, isotopes, isomers, isotones, isobars
  - **Radioactivity and radioactive decay and X-rays**  
Definition of radioactivity, stable and unstable nucleus, mode radioactive decay, alpha, beta, positron and gamma emission, electron capture, isomeric transition, equations of radioactive decay, half life, mean life, radioactive series, naturally occurring radionuclide, reactor produced radionuclide and cyclotron produced radionuclide. Definition of X-rays, characteristic X-rays, bremsstrahlung, X-ray production
  - **Electricity, Electromagnetism and Electronics**  
Paramagnetic, diamagnetic, and ferromagnetic substances, Conductor, semiconductors, insulators, AC and DC power supply, single phase and poly phase, switches, fuses, circuit, circuit breakers and earthing, Low tension and high tension electric connections, Ohm's law, Ammeter, voltmeter, Galvanometer, magnet and magnetic field  
Definition of electromagnetism, electromagnet, inductance, impedance, diode, triode, semiconductor diode and triode, avalanche diode  
Electromagnetic radiation
- **Basic chemistry in nuclear medicine**
  - **Structure of atom:**  
Introduction, Electronic structure of atom, Atomic number, Mass number, atomic size, atomic mass, isotopes
  - **Periodic table:**  
Element symbols & representation, group, period, Chemical and physical properties of groups and periods, molecules, ions, ionic size, Patterns existing in a periodic table
  - **Chemical element, compound & chemical bonding:**  
Introduction, Element, compound and radicals, chemical bond, Electrovalent or ionic bond, covalent bond, coordinate covalent bond, complex formation.
  - **Chemical reaction:**  
Introduction, Law of conservation of mass, Important Chemical reactions, reaction mechanisms - nucleophilic, electrophilic, aromatic, chemical and physical conditions required for chemical reaction.

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▪ **Basic biology in nuclear medicine**

• **Structure of Cell**

Ultra structure of prokaryotic and eukaryotic cells, organelles structure marker and function, Plasma membrane & cytoplasm, Nucleus & ribosomes Endoplasmic reticulum, Golgi complex, Endomembrane system, Mitochondria, cytoskeleton, extracellular matrix, cell-cell junctions

• **DNA, RNA and Protein**

Introduction, Structure of DNA, RNA and important human protein, function of DNA, RNA and important human protein, RNA, Synthesis of DNA, RNA and protein

• **Enzymes:**

Introduction, structure of enzyme, function of enzyme, enzyme and substrate reaction mechanisms, factors effecting enzyme-substrate reactions.

• **Vitamins:**

Introduction, function of vitamins, structure of some important vitamins, water soluble and non soluble vitamins, essential and non essential vitamins, source of vitamins, vitamins deficiency diseases

• **Cell cycle:**

Introduction of cell cycle, mitosis and meiosis, Different phases of cell cycle and their significance, cytokinesis, karyokinesis, Cell transportation and malignant tumor growth. Cell aging and death, Apoptosis.

• **Cell Physiology:**

Glycolytic and TCA cycles, mechanisms of transport across cell membrane

Tissue, organ and organ system

Introduction, structure of tissue, tissue system in human, human organ and organ system

• **Immunology:**

Introduction, lymph, component of blood, B-cell and T-cell lymphocytes, antigen, antibody, antigenic reaction, monoclonal and polyclonal antibody, antigen antibody complex, concept of receptors, characterization and its function. Receptor – ligand interaction. Conjugated antibodies, new generation antibodies, Cells & important cytokines, Host versus Graft reactions, host directed immuno therapies, immunobiology of cancer.

• **Introduction to Biology of cancer**

Neoplastic processes. Inflammatory & Degenerative processes. Classification and nomenclature of neoplasms. Concept of Cell doubling time and its implication in Oncology; Warburg effect and its implications in metabolic imaging, Apoptotic pathway and role of Annexin V.

▪ **Research Methodology**

• **Introduction to Research Methodology**

Understanding Research: Definition and significance of research, Types of research, Research approaches: Quantitative vs. Qualitative, The role of research in computer science. Research Process and Ethics: Steps in the research process, Research ethics and responsible conduct, Formulating research questions and objectives, Research problem identification.

Research Design and Sampling: Principles of research design, Types of research design, Sampling

techniques, Choosing the appropriate research design.

• **Quantitative Research Methods**

Data Collection and Measurement: Primary and secondary data, Data collection methods: Surveys, questionnaires, and observations, Measurement scales: Nominal, ordinal, interval, and ratio. Statistical Data Analysis: Measures of central tendency and variability, Data visualization techniques. Inferential Data Analysis: Hypothesis testing, Parametric and non-parametric tests, Statistical software tools.

- **Qualitative Research Methods**

Qualitative Data Collection and Analysis: Qualitative research methods, Data collection techniques:

Interviews focus groups, Coding and interpretation of qualitative data.

Content Analysis: What is content analysis? Types of content analysis (e.g., thematic analysis, textual analysis), Conducting content analysis in computer science research, Using software for content analysis.

Mixed-Methods Research and Reporting: Combining quantitative and qualitative methods, Reporting research findings, Ethical considerations in mixed-methods research Unit 4: Research Communication and Publishing Writing Research Papers: Structure of a research paper, Writing the abstract, introduction, literature review, and methodology sections, Citation and referencing.

Research Presentations and Visualizations: Preparing effective research presentations, Visual aids and slide design, Presenting quantitative and qualitative findings

Publishing Research: Journals vs. conferences, The peer-review process, Preparing manuscripts for submission, Ethical considerations in publishing including data privacy and security in publications.

**Course Outcomes:**

- To learn basic physics required in nuclear medicine
- To learn basic chemistry required in nuclear medicine
- To learn basic biology like immunology, biochemistry required in nuclear medicine
- To learn basic of research methodology

## MNMMI-102: Basic mathematics, statistics and computers in nuclear medicine (80 Hours)

Coordinators: Mr. Ashish Kumar Jha  
ashish.kumar.jha.77@gmail.com

### Course Details:

#### ▪ Basics of Mathematics and Statistics:

- **Numerical methods**  
Numerical methods, accuracy and errors on calculations, initial approximation and convergence criteria, Newton Raphson method.
- **Quadratic Expressions**  
Quadratic Expressions, Equations in one Variable, Extreme Values - Changes in sign and Magnitude, Quadratic Inequation
- **Theory of Equations**  
The relation between the roots and coefficients in an equation, Solving the equation when two or more roots of it are connected by certain relations
- **Matrices**  
Definition - Types of Matrices - Equality, Addition, Commutative and associative, Properties of Addition
- **Permutations & Combinations**  
Definition of linear and circular permutations, to find the number of permutations of 'n' dissimilar things taken 'r' at a time.
- **Binomial Theorem**  
Binomial theorem for positive Integral Index, Binomial coefficients and simple results on them, Numerically greatest term, Approximations using Binomial Theorem
- **Integration, differentiation, Trigonometric Functions, Exponential and Logarithmic Series**  
Integration and differentiation rules and formulae, Simpson 3/8 Rule for Integration, Taylor series of  $\ln(1+x)$ , Expansion for real x,  $\log(1+x)$  expansion, The Trapezoidal Rule, Simpson's Rule, successive differentiation & Leibnitz theorem. Logarithms; Definition, Laws of Logarithms, Rule for Change of Base, Common and Natural Logarithms, Definition of Trigonometric Functions, Identities. Introduction to Mathematical Transformation: Fourier Transform, Laplace transforms.
- **Probability**  
Random experiment, random event, elementary events, exhaustive events, mutually exclusive events
- **Random Variables and Distributions**  
Random variables, Distributive functions, probability distributive functions, Mean variance of a random variable
- **Compartmental analysis**  
Introduction, Definition of compartmental analysis, model of compartmental analysis

- **Counting statistic**

Precision and accuracy; normal (Gaussian) distribution, Poisson's distribution, standard deviation, propagation of errors, efficient distribution of counting time, chi-square test, t- test.

- **Statistics**

- **Statistical technique used in medical sciences**

Diagnostic accuracy, sensitivity, specificity, positive and negative predictive value. Probability of occurrence – use of Z and t tables. Sampling, Estimates and Hypothesis testing: Sampling methods, Random sampling and estimates of population parameters from samples. Sample statistics, Hypothesis testing. Drawing inferences and confidence limits. P values. Student's t test for comparing means. General and paired t tests. Special cases where Variances are unequal. Central Limit Theorem. Analysis of Variance- F- Distribution, Test for Homogeneity

of Variance One Way ANOVA, Comparison of Means of Multiple Groups By Partitioning of the total Sum of Squares as within and between Sum of Squares, Assumptions in ANOVA, Missing Values, Two Way ANOVA; Design of Experiments. Correlation and Regression: Pearson's Product Moment Correlation Coefficient, comparison of Correlation Coefficients, Partial and Multiple Correlation, Linear Regression Analysis

Interpretation of Regression Coefficients. Application of Correlation and Regression in Method Comparison and Evaluation. Nonparametric Statistics: Spearman's Coefficient of Rank Correlation, Chi Square Test. Nonparametric Methods for Hypothesis Testing Based on Ranks. Mann Whitney U Test, Wilcoxon Signed Rank test, T Test. Clinical Statistics: Cohort Studies, Case Control Studies, Sample Size calculations, Clinical Trials, Meta analysis. Demonstration of application Software's in Statistics

- **Basics of computer science**

- **Number system**

Binary, octal, decimal and hexadecimal, conversion from one system to another

- **Fundamentals of computer hardware**

Central processing unit (CPU), random access memory (RAM), read only memory (ROM), arithmetic and logic unit (ALU), peripheral device, input device: keyboard, mouse, scanner, output devices: Monitor, printer etc. Analog to digital converter (ADC) and digital to analog converter (DAC)

- **Operating systems**

Introduction to computer operation system i.e. DOS, Windows, Linex,

- **Networking**

Introduction, principles of networking, various type of network topology, LAN, WAN, MAN and internet, Data transfer protocol, TCP/IP, FTP

- **Basics of software programming**

Introduction and programming in visual basic, C and C++, Python, R, Matlab, VB script, Java script, HTML

Relevant packages in Python, R, Matlab relevant to medicine and their uses

**Course Outcomes:**

- To learn basic mathematics required in nuclear medicine
- To learn statistics required in nuclear medicine
- To learn basic computer science required in nuclear medicine

## **NMMMI-103 Human anatomy, physiology and Patient Care (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
[ashish.kumar.jha.77@gmail.com](mailto:ashish.kumar.jha.77@gmail.com)

### *Course Details:*

- **Human anatomy, physiology**
  - **Basic concept of anatomy and physiology**  
Introduction, Definition of anatomy, definition of physiology
  - **Musculoskeletal system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Cardiovascular system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Lymphatic system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Respiratory system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Gastrointestinal system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Hepatobiliary system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Genitourinary system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Nervous system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Endocrine system**  
Introduction, Anatomy, radiological anatomy, physiology and pathological conditions
  - **Receptor systems**  
Introduction, physiology and pathological conditions
- **Hospital ethics and patient care**
  - **Hospital administration and ethics**  
Introduction, structure of hospital, working of hospital, hospital ethics
  - **Departmental procedure**  
Introduction, structure of nuclear medicine department, functioning of nuclear medicine department, Good working practice, responsibility in the department, emergency in nuclear medicine department
  - **Patient Care:**  
Introduction, working with patient, aseptic practices, care to the patient

- **First aid and Cardio Pulmonary Resuscitation**  
Theory and Practical

***Course Outcomes:***

- To learn human anatomy and physiology required in nuclear medicine
- To learn patho-physiological conditions relevant in nuclear medicine
- To learn hospital ethics and patient care required in nuclear medicine

## **NMMI-201: Radiation Physics and Radiation Safety in Nuclear medicine and Cyclotron (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### **Course Details:**

#### **▪ Nuclear medicine physics**

##### **• Basic Radiation Physics**

Atomic structure, atomic number, mass number, isotopes, radioisotopes, radioactivity, specific activity, types of radioactive disintegrations, electron capture, characteristics of alpha, beta and gamma rays, energy of ionizing radiation, half-life (physical, biological), effective half life, isomeric transition, secular, transient and no equilibrium, production of radioisotopes and x-rays (characteristics and bremsstrahlung), neutron sources.

##### **• Interaction of Radiation with Matter**

Interaction of Photons with Matter, Types of Photon Interactions in Matter (Compton Scattering, Photoelectric Effect, Pair production, Attenuation of Photons in Matter, linear attenuation coefficient, mass attenuation coefficient, Half-Value and Tenth-Value Layers

##### **• Interaction of Charged Particles with Matter**

Excitation, Ionization, Specific Ionization, Linear Energy Transfer, Annihilation, Bremsstrahlung

##### **• Radiation Quantities and Units**

Activity(Becquerel/Curie), exposure(C/kg /Roentgen), air kerma, absorbed dose (Gray/Rad), radiation weighting factors(WR), tissue weighting factors(WT), equivalent dose (Sievert/Rem), effective dose (Sievert/Rem), Collective Effective dose (Person Sv), Annual Limit of Intake{ALI}, Derived Air Concentration {DAC} (Becquerel/m<sup>3</sup>).

##### **• Radiation Detection & Measurement**

Principle of radiation detection, gas detectors (ionization chamber, proportional counter and GM counter), solid state detectors (scintillators, semiconductors and Thermoluminescent Dosimeters {TLD}), liquid scintillation counting systems, radiation monitoring instruments, personnel monitoring, area monitoring, environmental monitoring, direct reading devices, calibration and response of radiation monitoring instruments.

##### **• Biological Effects of Radiation**

Interaction of radiation with cell, direct and indirect interactions, mechanism of radiation damage in living cells, individual organ damage, pre-natal effects, modifying factors, chromosomal aberration, deterministic and stochastic effects, partial body and whole body exposures.

##### **• Operational Limits**

Introduction to natural background radiation, concept of occupational risk, philosophy of radiation protection, system of dose limitation, ALARA, dose limits to radiation workers and general public, AERB/ICRP recommendations, dose constraints for comforters of patients.

##### **• Radiation Hazard Evaluation and Control**

Internal and external radiation hazards and their perspective, evaluation and control of hazard due to external radiation, individual and workplace monitoring, application of time, distance

and shielding; specific gamma ray constant, external radiation monitoring, survey meters, internal hazard evaluation, and control, protective measures for handling of unsealed sources (eg. Fume-hood, glove box), environmental control, protective clothing, contamination monitoring (direct and indirect), air contamination monitoring, personnel contamination monitoring and decontamination procedures, surface decontamination procedures.

- **Planning of Nuclear Medicine (NM) Laboratories**

Classification of NM Laboratories, general features of NM laboratories (site, typical floor plans, ventilation, surface, walls, floor and ceiling, work surfaces, containment systems, fume-hood, glove box etc.), planning of various categories of NM laboratories, such as diagnostic and high dose therapy, PET-CT and Medical Cyclotron installation, shielding evaluation of NM laboratories as per source term, model layout of various NM laboratories.

- **Transport of Radioactive Material:**

Types of packages, category of packages, procedure for marking, labeling, transport index, transport documents, procedures for preparation and forwarding of packages, instruction to the carrier, nature of radiation hazard, rules governing transport of radioactive materials, off-normal situation during transport of radioactive materials, surface contaminated objects, handling of off-normal situations, emergency planning, responsibilities of consigner and consignee

- **Radiation Accidents, Case Studies, Lessons Learn**

Radiation accidents involving radioisotopes, orphan and vulnerable sources, handling of emergency situations resulting from spillage of radiopharmaceuticals/liquid radioisotopes, misadministration of radiopharmaceuticals, consequences of misadministration, general methods of prevention of accidents, loss of radioisotope, fire accidents and explosions : follow up actions through emergency response plan, case studies and mitigation, lessons learn.

- **Disposal of Radioactive Waste**

Origin and type of waste, classification of wastes and methods of disposal, disposal of short-lived solid, liquid and gaseous radioactive waste, disposal of animal carcasses, disposal of radioactive foliage, disposal limits for ground burial and sanitary sewage system, incineration, disposal of long-lived and indispersible radioactive wastes.

- **Regulatory Aspects for Nuclear Medicine Laboratories**

Regulations with respect to nuclear medicine laboratories, relevant regulatory document such as Act, Rules, Code and Guides, responsibilities of employer, licensee, Radiation Safety Officer (RSO), technologist and radioisotope supplier, safety and security of radiation sources, regulatory requirements for import/export, procurement, use, handling, transfer and disposal of radioisotopes, inventory control, Radiation Protection Program (RPP).

- **Emergency Response Plans and Preparedness**

Normal and potential exposures, potential accident situations involving radioisotopes, elements of emergency planning and preparedness, administrative and technical procedures

- **Responsibilities of Radiation professionals work in nuclear Medicine**

Role and responsibilities of employer, licensee, Nuclear Medicine physician, RSO, technologist, and radioisotope supplier

- **Radiation Safety Considerations in Cyclotron faculty**

Normal and potential exposures, potential accident situations involving failure of isotope production, failure of equipment, servicing of cyclotron, elements of emergency planning and preparedness, administrative and technical procedures, radioisotope dispatch.

**Course Outcomes:**

- To learn basics of Radiation Physics required in nuclear medicine
- To learn basics of Radiation Biology required in nuclear medicine
- To learn basics of Radiation Protection and Safety required in nuclear medicine practice.
- To learn basics of Radiation Protection and Safety required in Medical Cyclotron

## **NMMMI-202: Non-imaging and Imaging Instrumentation in nuclear medicine (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### **Course Outcomes:**

- To learn basic principle, working principle, instrumentation and quality control of non-imaging instruments used in nuclear medicine
- To learn basic principle, working principle, instrumentation and quality control of imaging equipment used in nuclear medicine

### **Course Details:**

#### **▪ Instrumentation**

- **Non scintillation (Gas filled) Detectors**

Gas-Filled Detectors, Characteristics of the Major Voltage Regions Applied Across a Gas-Filled Detector, recombination region, ionization region, proportional region, region of limited proportionality, Geiger Muller region, continuous discharge, Ionization Chambers, Semiconductor Detectors

- **Scintillation Detectors**

Structure and Characteristics of the Crystal Scintillation Detector, Photomultiplier Tubes, Preamplifiers and Amplifiers, Pulse-Height Analyzer, Sodium Iodide Detector Energy Spectrum, Photo peak, Compton Peak (or Compton Edge), Iodine Escape Peak, Annihilation Peak, Coincidence Peak, Backscatter Peak, Characteristic Lead X-Ray Peak, Characteristics of Scintillation Detectors, Energy Resolution, Decay Time, Efficiency, Thyroid Probe, Well Counter, Dosimeters and Area Monitors

- **Liquid Scintillation Detector**

Working of Liquid Scintillation Detector

- **Non imaging Devices**

- Dose Calibrator

Working Principle, Instrumentation, Quality Assurance and Quality Control (Accuracy, Constancy, Linearity, Geometry)

- Survey Meters

Names and Types – Pan-cake, End window, etc; Working Principle, Instrumentation and Quality Assurance and Quality Control (Constancy, Calibration) of each type

- Spectrometer

Working Principle, Instrumentation, Quality Assurance and Quality Control (Linearity, Geometry, Energy Resolution, Calibration, Efficiency)

- Geiger Muller Counter

Working Principle, Instrumentation, Quality Assurance and Quality Control (Calibration, Efficiency, Accuracy, Constancy, Linearity, Geometry)

- **Thyroid Probe**  
Working Principle, Instrumentation, Quality Assurance and Quality Control (Iso response curve, Calibration, Efficiency)
  - **Gamma Probe**  
Working Principle, Instrumentation, Quality Assurance and Quality Control (Resolution, Calibration, Efficiency)
  - **TLC Scanner**  
Working Principle, Instrumentation, Quality Assurance and Quality Control (Linearity, Geometry, Energy Resolution, Calibration)
  - **HPLC Scanner**  
Working Principle, Instrumentation, Quality Assurance and Quality Control
  - **Gas chromatography:**  
Working Principle, Instrumentation, Quality Assurance and Quality Control
  - **Imaging Instrumentation**  
Introduction, Components of the Imaging System, Collimators, Parallel-Hole Collimators, High-resolution collimators, High- and medium-energy collimators, Slant-hole collimators, Nonparallel-Hole Collimators, Converging and diverging collimators, Pinhole collimators, Fan-beam collimators, Camera Head, Crystals, Photomultiplier Tubes, Preamplifiers, and Amplifiers, Positioning Circuit, Pulse-Height Analyzer, Persistence Scope, Computers, matrix and pixels, Planar Imaging, Image Acquisition, Static Images, Dynamic Images, Gated Images
  - **Single-Photon Emission Computed Tomography (SPECT)**  
Introduction, Types of Cameras, Angle of Rotation of Heads, Two-Headed Cameras: Fixed and Adjustable, Acquisition, Arc of Acquisition, Number of Projection Tomographic Views, Collection Times, Step-and-Shoot vs. Continuous Acquisition, Circular vs. Elliptical Orbits, Patient Motion and Sinograms, Reconstruction, Filtered Backprojection, Backprojection, Signal vs. Noise, Filtering, Filtering in the Spatial Domain, Spatial Filtering to Reduce Noise: Nine-Point Smoothing, Spatial Filtering to Reduce the Star Artifact, Filtering in the Frequency Domain, Fourier transformation, Nyquist Frequency, Signal, Noise, and the Star Artifact in the Frequency Domain, Frequency Filtering to Reduce the Star Artifact, Low-Pass Filters, Types of low-pass filters, Cutoff frequency and order, Filter Selection, Attenuation Correction, ordered subsets expectation maximization (OSEM), Post-reconstruction Image Processing, Creation of Sagittal, Coronal, and Oblique Slices
  - **Positron Emission Tomography (PET)**  
Introduction, Advantages of PET Imaging, Sensitivity, Resolution, Coincidence Detection, line of response (LOR), Time of Flight, PET Camera Components, Crystals, Photomultiplier Tubes, Pulse Height Analyzers, Timing Discriminators and Coincidence Circuits, Septa, Factors Affecting Resolution in PET Imaging, Positron Range in Tissue, Photon Emissions Occurring at Other than 180, Parallax Error, Reconstruction and Post- Reconstruction Processing, Attenuation in PET Imaging, Attenuation Correction, Standard Uptake Values
  - **Computed Tomography**  
Introduction, X-Ray Production, x-ray tube, X-Ray Imaging, Computed Tomography, detector system, single and multi row detector, Axial and Helical Scanning, Hounsfield Units,
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## **NMMMI 203:Radio-chemistry, Radio-pharmacy and Basic Clinical Practice (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
[ashish.kumar.jha.77@gmail.com](mailto:ashish.kumar.jha.77@gmail.com)

### *Course Details:*

- **Hospital radiopharmacy practices and GMP**  
Introduction to hospital radiopharmacy practices, Good manufacturing practices
- **Radionuclides used in nuclear medicine**  
Introduction to important radionuclides, physical properties, chemical properties, ideal radionuclides for diagnosis, therapy.
- **Generator systems:**  
Basic principle of radionuclide generator, Type of radionuclide Generator, Various radionuclide Generator used in nuclear medicine
- **Analytical tools used in Radiopharmacy**  
Chromatographic techniques and instrumentation: TLC, ITLC, HPLC
- **Conventional radiopharmacy**  
Radiopharmaceuticals used in nuclear medicine  
Structure of pharmaceuticals, labeling, quality control and bio-distribution of Tc99m radiopharmaceuticals  
I-131 radiopharmaceuticals In-111 radiopharmaceuticals Tl-201 radiopharmaceuticals Ga-67 radiopharmaceuticals
- **Intervention drugs:**  
Introduction, important intervention drugs used in nuclear medicine procedure, pharmacology and mechanism of action
- **Emergency drugs:**  
Introduction, emergency drugs, mechanism of action, indication for use
- **Non-imaging applications of radionuclides**  
51Cr labeled RBC's for blood volume, red cell volume measurement, spleen uptake, red cell survival studies. Schilling's test using 58Co/57Co for vitamin B12 absorption, applications of 14C radiorespirometry for H.Pylori ulcers, Ferrokinetic studies using radioisotopes of Iron.
- **Diagnostic In-vitro Techniques:**  
Principle of RIA, Immunoradiometric assay (IRMA), Enzyme linked immunosorbent assay (ELISA), Fluorescent immunoassay (FIA), Chemiluminescent Immunoassay (CLIA), Methods of receptor assays. In-vitro Uptake studies, In-vitro radiorespirometry, Quality Control Parameters and methods and Applications for hormones & drugs, example of assays for T3, T4, TSH, free hormones, thyroid antibodies and thyroglobulin, other hormones and drugs.
- **In-vivo non-Imaging:**  
Thyroid uptake, GFR estimation using plasma sampling.
- **Scintigraphy technique**  
Basics Scintigraphy, Common scintigraphy techniques of Brain, Pulmonary system, cardiovascular

system, gastrointestinal system, hepatopancreatic system, renal system musculoskeletal system.

**Course Outcomes:**

- To learn Hospital Radio-pharmacy practices and GMP required in nuclear medicine
- To learn about the various aspects i.e. generator systems, formulation, quality control, quality assurance of conventional radiopharmaceuticals used in diagnostic nuclear medicine
- To learn about the various aspects i.e. formulation, quality control, quality assurance of conventional radiopharmaceuticals used in therapeutic nuclear medicine
- To learn about the various aspects various aspects of clinical practice in nuclear medicine

## **NMMMI:301 Advanced Clinical Nuclear Medicine (80 Hours) (09-HLTH19-201-C)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### *Course Details:*

- **Nuclear medicine facility**  
Introduction, requirement to open a nuclear medicine facility
  - **Nuclear medicine diagnostic and therapeutic procedure**  
Introduction, important diagnostic and therapeutic procedure
  - **Introduction ECG study**  
Introduction, 12 Lead ECG, normal ECG graph
  - **Scintigraphy and data processing of following systems**  
Indication to do the scan, patient scheduling, patient preparation, dose formulation and dispensing, dose administration, post administration patient counseling, setting acquisition parameters, patient positioning, data acquisition, data processing, saving processed data and giving printout
    - **Musculoskeletal system**  
Whole body bone scan, Three Phase Bone Scan, Bone SPECT , DEXA Scan
    - **Cardiovascular system**  
Equilibrium Gated Radio nuclide ventriculography (MUGA scan), Myocardial Perfusion Scintigraphy (MPI), Myocardial infarction Scintigraphy, First Pass  
  
Study, Nannocolloid bone marrow Scintigraphy
    - **Lymphatic system**  
Lymphoscintigraphy, Sentinel node Scintigraphy
    - **Respiratory system**  
Lung Perfusion Scintigraphy, Lung ventilation Scintigraphy, Aerosol clearance study, Mucocilliary clearance imaging
    - **Gastrointestinal system**  
Salivary Scintigraphy , Salivagram, Gastroesophageal Reflux Scintigraphy, Esophageal Transit Time Scintigraphy, Gastric Emptying Scintigraphy, Meckel's Scintigraphy, Gastrointestinal bleed study, schilling's Test
    - **Hepatobiliary system**  
Hepatobiliary Scintigraphy(HIDA), Liver Blood Pool(Hemangioma) Scintigraphy, Tc99m-Sulfur colloid Scintigraphy
    - **Genitourinary system**  
Renogram GFR study, GFR Estimation by Blood Sampling Method, Renal Transplant evaluation, Assessment of Renovascular Hypertension, Tc99m-DMSA renal Scintigraphy, Direct radionuclide cistourethrography(DRCG) and indirect radionuclide cistourethrography(IRCG), Scrotal Scintigraphy
    - **Nervous system**
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Brain perfusion study, Radionuclide Cisternography, TRODAT Imaging, DOPA Imaging, Amyloid imaging

- **Endocrine system**

Thyroid uptake and Scan (Tc99m – TcO<sub>4</sub> Thyroid scan, I-131- Thyroid scan, Perchlorate discharge test), Parathyroid Scan(Tl-201 – Tc99m Dual subtraction Scintigraphy, Tc99m-MIBI Scintigraphy)

- **Receptor systems**

I-131-MIBG Scan, Tc99m-Tumor Scintigraphy, Tc99m-DOTA Whole body Scintigraphy, In-111- Octreotide whole body Scintigraphy, Tc99m- DAT and TRODAT Brain Scintigraphy

- **In-Vitro Nuclear Medicine:**

Blood Volume estimation annocolloid bone marrow Scintigraphy, GFR by plasma sampling method, RIA, IRMA

- **In vivo non imaging:**

Thyroid Uptake, Urea breath test,

- **Dacryoscintigraphy**

- Scintimammography

Early and Delayed Imaging. Special Positions and Restraining means.

- **Salivary gland imaging**

Imaging for parenchymal and obstructive diseases of salivary glands. Post Radiation Xerostomia evaluation.

- **Bone marrow imaging**

Imaging techniques for visualisation of Bone marrow infiltration

- **Positron Emission Tomography /Computer Tomography Imaging**

HRCT Thorax, HRCT Bone,

Contrast Enhanced Computer Tomography Brain Contrast Enhanced Computer Tomography Head & Neck Contrast Enhanced Computer Tomography Thorax Contrast Enhanced Computer Tomography Abdomen Contrast Enhanced Computer Tomography Pelvis

Tri-phasic Computer Tomography Computer Tomography Perfusion study Whole body FDG PET/CT SCAN

Whole body contrast enhanced FDG PET/CT SCAN PET/CT FDG Brain Scan

PET/CT contrast enhanced FDG Brain Scan PCT/CT FDG Cardiac Scan

Dynamic PET imaging

**Course Outcomes:**

- To learn various imaging procedures of nuclear medicine applied in diagnosis
- To learn various advanced procedures of nuclear medicine applied in diagnosis

## NMMMI 302: Advanced Radio-chemistry and Radio-pharmacy (80 Hours)

Coordinators: Mr. Ashish Kumar Jha  
ashish.kumar.jha.77@gmail.com

### Course

#### Course Details:

- **Reactors:**  
Basic Physics of nuclear reactors, Reactor produced radio nuclides, fission reaction, neutron capture or (n,  $\gamma$ ) reaction, targets used for production and its processing, equation of production of radionuclide, specific activity
- **Cyclotron:**  
Basic Physics of cyclotron, Basics of medical cyclotron operation, Basics methods of radionuclide production in cyclotron
- **PET radiopharmacy**  
PET radionuclide production, separation and purification  
PET radiopharmaceutical synthesis, quality control and biodistribution  
Receptor based PET radiopharmaceuticals 18F-FDG, 18F-FLT, 18F-FET, 18F-MISO 18F-DOPA synthesis and quality control  
18F -Amyloid synthesis and quality control
- **Ga- Radiopharmaceuticals**  
Synthesis, Purification and quality control of peptide based radiopharmaceuticals 68Ga- DOTATOC, 68Ga-PSMA, 68Ga-RGD, 68Ga-Excedrin  
Synthesis, Purification and quality control of radiopharmaceuticals like 68Ga-Zoledronate, 68Ga-MAA, 68Ga-EDTA
- **Therapeutic radiopharmaceuticals**  
Synthesis, Purification and quality control of peptide based radiopharmaceuticals 177Lu- DOTATOC, 177Lu-PSMA,  
Synthesis, Purification and quality control of Monoclonal antibody and other biomolecule based radiopharmaceuticals 177Lu-Trastuzumab, 131I- Rituximab
- **Development of radiopharmaceuticals:**  
Empirical and Rational approaches to design, charge and size of the molecule, protein binding solubility, stability and bio-distribution. Structure- activity relationship. Biological properties of radiopharmaceuticals, pharmacokinetics, distribution, metabolism, excretion.

#### Outcomes:

- To learn advance radiochemistry used for production & purification of radionuclides in reactors and accelerators (cyclotron) in nuclear medicine
  - To learn advance radiochemistry used in preparation of positron emitting radiopharmaceuticals used in diagnostic nuclear medicine
  - To learn advance radiochemistry used in preparation of 68Ga radiopharmaceuticals used in diagnostic nuclear medicine
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- To learn advanced radiochemistry used in preparation of peptide, biomolecule-based radiopharmaceuticals used in therapeutic nuclear medicine

## **NMMMI 303: Therapeutic Nuclear Medicine & Radiation Dosimetry (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
[ashish.kumar.jha.77@gmail.com](mailto:ashish.kumar.jha.77@gmail.com)

### **Course Details:**

- **Radiation Dosimetry**  
Compartmental Model (Single compartment, two compartmental model with and without back transference, In-vivo dosimetry using classical dosimetry mechanism (Beta dosimetry, gamma dosimetry, geometrical factor, dosimetry of low energy electromagnetic radiation), MIRD formulation (cumulated activity, equilibrium absorbed dose constant, absorption factor, specific absorbed fraction and the dose reciprocity theorem, mean dose per cumulated activity, limitation of MIRD method) extremity dosimetry mechanism using various detectors.
- **Radionuclide Therapy- Radiation Safety Aspects**  
Radionuclide administration techniques, pre-and-post therapy precautions, nursing care, patient monitoring and discharge criteria, optimization of radiation dose to non-target tissues, radiation safety consideration in palliative bone metastases treatment, radiation safety during other therapeutic procedures such as radiation synovectomy, peptide therapy etc.
- **Clinical and Patient Management Aspect of Radionuclide Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient
- **I-131 Low dose Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient
- **I-131 high dose Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient
- **I-131 MIBG Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient
- **Bone Pain Palliation Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient
- **Receptor based Therapy**  
Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post

administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient

▪ **Radiation Synovectomy**

Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient

▪ **Trans arterial radioembolisation (TARE)**

Indication to give therapy, Radionuclide therapy planning and patient specific MIRD, Patient scheduling, Patient preparation, Formulation of radiopharmaceuticals, Dose dispensing, pre and post administration patient counseling, Post administration radiation survey, Record keeping, Discharge criteria of patient

**Course Outcomes:**

- To learn radiation safety aspects and radiation dosimetry involved in radionuclide therapy
- To learn clinical application and patient management aspects of radionuclide therapy
- To learn advanced aspects of internal dosimetry radionuclide therapy

## **NMMMI 401:Advanced Instrumentation in Nuclear Medicine & Molecular Imaging (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### *Course Details:*

- **Multicrystal Gamma Camera**  
Emerging designs and considerations of Multicrystal Gamma Camera. Small animal imaging systems
  - **Magnetic Resonance Imaging**  
Introduction, Principals of MRI, Magnets in MRI, RF coils, MRI imaging, Imaging sequences in MRI, Functional MRI, MRI spectrometry
  - **Biomedical Ultrasound**  
Ultrasound generators, properties of ultrasound wave and its propagation in biological tissues, Pulse echo techniques, Scan types. Doppler principle.
  - **Positron Emission Tomography/ Computed Tomography (PET/CT) Imaging**  
Introduction to PET/CT, PET-CT Cameras, Current advancement in PET-CT Imaging, Dynamic PET imaging Technique
  - **Positron Emission Tomography/ Magnetic Resonance Imaging (PET/MRI) Imaging**  
Introduction to PET/MRI, PET/MRI fusion, challenges in PET/MRI
  - **Cyclotron**  
Introduction, working principle, instrumentation, operation and quality assurance.
  - **Instruments Used in External Beam Radiotherapy, Brachytherapy**  
Introduction, working principle and operations of following equipments- Cobalt-60 unit (Bhabhatron), LINAC, IGRT, Tomotherapy, IMRT, Gamma Knife, Proton Beam Therapy
  - **Effective use of computers in nuclear medicine**  
  
Introduction, Signal processing, Curve processing, compartment modeling, quantitative studies, invivo quantification of tracer distribution and advance algorithm of internal Dosimetry, various algorithm for image processing.
  - **Image formation**  
Bit, Bite, Word, Matrix, Pixels and Voxels, image formation, Dicom format of image and PACS system
  - **Hardware and software fusion**  
Introduction, software and hardware fusion concept, merits and demerits of software and hardware fusion
  - **Neural network**  
Introduction & scope.
  - **Quality Assurance and Quality Control**
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Introduction and overview of Quality Assurance program in nuclear medicine, difference between quality control and quality assurance. Basic indices for NABL accreditation of NM laboratories. Good manufacturing Practices (GMP) and Good Clinical Practices (GCP).

- **Planar Gamma Camera**  
Photopeak, extrinsic and intrinsic Flood field Uniformity, integral and differential uniformity, Correction of Nonuniformity, Spatial Resolution, Line Spread Function, full-width at half-maximum (FWHM), Linearity, NEMA specifications and periodic tests, periodic maintenance
- **Single-Photon Emission Computed Tomography (SPECT)**  
Uniformity, Center of Rotation, Measuring SPECT Uniformity and Resolution with a Phantom, NEMA specifications and periodic tests), periodic maintenance
- **Positron Emission Tomography (PET)**  
(Blank Transmission Scans, PMT Gain Test, Normalization, Calibration, Coincidence timing test, Energy resolution, NEMA specifications and periodic tests), periodic maintenance

- **Computed Tomography (CT)**  
Tube Warm Up; Air Calibration; Radiation Safety Performance Test: Slice Thickness, Accuracy of Operating Potential, Accuracy of Timer, Coefficient of Length, Coefficient of Volume, CTDI test, High & Low contrast resolution, Total Filtration, Radiation Leakage test; Gantry table alignment; Table indexing Accuracy, periodic maintenance
- **Magnetic Resonance Imaging (MRI)**  
Geometric accuracy (mm), High-contrast spatial resolution (mm), Slice thickness accuracy (mm), Slice position accuracy (mm), Image intensity Uniformity (%), Percent signal ghosting (%), Low-contrast object detectability (contrast level), Signal-to-noise ratio, Central frequency (Hz), periodic maintenance

▪ **Artificial Intelligence and machine learning**

- **Introduction to AI and ML in Medical Physics**  
Fundamentals of AI and ML: Define artificial intelligence, machine learning, deep learning, and their distinctions. Discuss the different types of learning (supervised, unsupervised, and reinforcement learning) with medical examples.  
Data in Medical Physics: Understand the importance of big data in medicine. Learn about different types of medical data (DICOM, imaging data, patient records) and the crucial processes of data collection, curation, and preprocessing.  
Ethical and Regulatory Considerations: Explore the challenges, ethical issues, and biases associated with using AI in healthcare. Discuss regulatory frameworks like HIPAA and the role of the medical physicist in clinical implementation, commissioning, and quality assurance of AI tools.
- **Machine Learning Fundamentals**  
Core Concepts: Introduce essential ML concepts such as features, training, validation, testing, overfitting, and underfitting. Learn about common performance metrics like accuracy, sensitivity, specificity, and the Receiver Operating Characteristic (ROC) curve.  
Classical ML Algorithms: Cover key algorithms including support vector machines (SVMs), decision trees, and random forests.  
Deep Learning Introduction: Provide an overview of neural networks, their architecture, and the concept of deep learning. Explain the function of different layers (input, hidden, output) and activation functions.

- **AI in Medical Imaging**

Image Processing and Analysis: Review foundational image processing techniques. Introduce radiomics and image segmentation using ML algorithms.

AI-Powered Image Reconstruction: Explore how AI can be used for image reconstruction from low-dose or limited data (e.g., CT, PET, MRI). Discuss its potential for reducing patient dose while maintaining or improving image quality.

Computer-Aided Diagnosis (CAD): Examine how AI models are used for computer-aided detection (CADe) and diagnosis (CADx) of diseases in various imaging modalities.

Image Registration and Synthesis: Learn about automated image registration, a process critical for combining images from different modalities (e.g., PET-CT). Introduce

Generative Adversarial Networks (GANs) for generating synthetic images, such as creating a synthetic CT from an MRI for treatment planning.

**Course Outcomes:**

- To learn basic principle, working, instrumentation and quality control of imaging equipments used in nuclear medicine
- To learn basic principle, working, instrumentation and quality control of Medical Cyclotron
- To learn basic principle, working and instrumentation of instruments/ equipments used in external beam Radiotherapy, Brachytherapy
- To learn the basics of machine learning algorithm, radiomics and its application in nuclear medicine and oncology

## PRACTICALS

### NMMMI104 Basic sciences and Computer programming and hardware (40 Hours)

Coordinators: Mr. Ashish Kumar Jha  
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- **Basic sciences**
  - Inverse square law
  - Find out half value layer (HVL) Shielding measurement
  - Radiation Exposure – effect of distance
  - Dispensing of known amount of isotope and finding out dispensing error Pipetting of known amount of isotope and finding out pipetting error Finding the unknown volume using dilution principles
  - To find out half life of radio radionuclides using dose calibrator pH measurement
- **Computer hardware and programming**
  - Identification of computer hardware and peripheral system
  - Assembling a computer and connecting peripheral system like keyboard, mouse, monitor, printers and scanners etc.
  - Switching on and off nuclear medicine equipments Configuring network connection on a computer Sharing resources on network using share permission
  - Preparation of power point presentation and word document
  - Performing various mathematical and statistical calculation using MS excel
  - Performing addition, subtraction, multiplication, division using C, C++, Python, R, VB script and Java script
  - Estimation of pixel size of Gamma camera

#### **Course Outcomes:**

- Understand and strengthen concepts of basics of -electronics, -mathematics and statistics related to nuclear medicine.
- Learn origin and types of radiation and its practical considerations
- Learn computer application and programming and execution of computer program

## **NMMMMI105:Radiation protection in nuclear medicine and cyclotron (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha  
ashish.kumar.jha.77@gmail.com**

- Understand and implement the concept of radiation protection in nuclear medicine and cyclotron

### ***Course Details:***

- Record keeping in Nuclear medicine
- Bio-distribution study of various radiopharmaceuticals Radiation Survey of SPECT facility
- Radiation Survey of PET facility Radiation Survey of Cyclotron facility
- Radiation Survey of Radionuclide therapy facility
- Swipe sampling and measurement of loose contamination
- Sampling and measurement of radioactivity concentration in sewerage discharge Finding our derived air concentration (DAC)
- Preparation of decontamination kit Decontamination procedure for personal and facility Patient monitoring and confinement
- Preparation of decontamination report
- Radiation dose estimation post exposure due to radioactive spillage in nuclear medicine

### ***Course Outcomes:***

- Understand and strengthen concepts of radiation physics, radiation safety

## **NMMMI 204:Radio-chemistry, Radio-pharmacy and basic clinical practice (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### **Course Details:**

#### **▪ Radio-chemistry & Radio-pharmacy**

- QC of Radiopharmaceuticals
- Visual Inspection (colour, turbidity, clarity)
  
- Radionuclidic purity: Gamma scintillation spectrometry, Differentialattenuation (Mo breakthrough test)
- Radiochemical purity (chromatographic and other separation methods)
- Chemical Purity (chromatographic method: Paper chromatography technique, TLC, HPLC)
- Sterility test (Endotoxin test) Formulation of Tc compounds from kit
- Determination of <sup>99</sup>Mo breakthrough in <sup>99m</sup>Tc elute Radiopharmacy procedures – Elution of generator
- Preparation of different radiopharmaceuticals and their quality control

#### **▪ Clinical practice**

- In-vitro sampling and measurement Plasma sampling GFR estimation Thyroid Uptake using uptake probe Thyroid scan using Gamma Camera GFR estimation using gamma camera Planer whole body Bone scan

### **Course Outcomes:**

- Understand and strengthen concepts radio-chemistry and radio-pharmacy
- Learn and implement of various radiochemistry and radio-pharmacy concepts
- Understand and implement the concept of vitro and in vivo nuclear medicine technique

## **NMMMI 205:Quality control of non-imaging Equipment (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### ***Course Details:***

- Plateau of G.M. Counter Dead time of G.M. Counter Back scatter experiment
- Gamma Probe Quality Control
- Thyroid uptake Quality Control and iso-response curve of flat field collimator Finding accuracy and precision of isotope calibrator
- Finding linearity of isotope calibrator Finding constancy of isotope calibrator Finding syringe factor of isotope calibrator Liquid Scintillation Counting
- Well counter Quality Control
- Efficiency of Gamma Ray Spectrometer (Well counter) Linearity of Gamma Ray Spectrometer (Well counter) Critical volume Gamma Ray Spectrometer (Well counter)

### ***Course Outcomes:***

- Understand and strengthen concepts non imaging instrumentation and quality control
- Learn and implementation of quality control of non-imaging nuclear medicine instrument

## **NMMMI 304: Advanced Clinical Nuclear medicine (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

- **Patient preparation, imaging and image processing of various scintigraphy**
  - Brain imaging
  - GI system imaging
  - Hepatobiliary
  - imaging Salivary
  - Imaging Renal
  - Imaging Cardiac imaging
  - Lung imaging
  - Musculoskeletal imaging
  - Lymphoscintigraphy
  - Thyroid uptake and imaging
  - Para-Thyroid imaging
  - Antibody imaging
  - Dosimetry scans
  - Whole body non-contrast PET/CT
  - Whole body contrast PET/CT (18F-FDG, 18F-FET, 18F-FDOPA, 18F-DOTA, 18F-PSMA, 68Ga- DOTA, 68Ga-FAPI, 68Ga-PSMA, 68Ga-RGD)
  - Infection imaging

### ***Course Outcomes:***

- Understand and strengthen concepts clinical nuclear medicine
- Learn and perform the various advanced nuclear medicine clinical diagnostic procedure

## **NMMMMI 305: Quality control of Imaging Equipment (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### ***Course Details:***

- **Preparation of various SPECT Phantom for quality control Preparation of various PET Phantom for quality control Phantom studies for Scintigraphy**
- **Flood field uniformity intrinsic/extrinsic**
- **QC of Gamma camera with SPECT/CT(Uniformity, Linearity, Spatial Resolution, Energy Resolution, Centre of Rotation, Sensitivity, Detector Shielding, Count Rate Performance, QC of CT- uniformity, contrast test, Registration- SPECT-CT)**
- **QC for PET (Coincidence timing test, Energy resolution, System correction- normalization, Calibration & Blank Scan)**
- **Point and Line Spread Function in PT and SPECT**
- **CT quality control acceptance tests (Slice width, Dose Profiles,**
  - Slice width,
  - Dose Profiles
  - Accuracy of X-Ray Tube Voltage (kV)
  - Linearity of X-Ray Tube Current (mA)
  - Accuracy of Irradiation Time (t)
  - Consistency of Radiation Output
  - Radiation Quality (Total filtration – HVL)
  - Radiation Dose Test
  - Dosimetry (CTDI, DLP) Image Quality Parameters
  - CT number Uniformity
  - CT number Linearity
  - Noise
  - Low contrast resolution
  - Spatial resolution

### ***Course Outcomes:***

- Understand and strengthen concepts quality control of imaging equipment
- Learn and perform the various quality control of imaging equipment used in nuclear medicine

## **NMMMI404: Advanced radiochemistry and Radio-pharmacy (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
[ashish.kumar.jha.77@gmail.com](mailto:ashish.kumar.jha.77@gmail.com)

### ***Course Details:***

- **Diagnostic radiopharmaceuticals**  
Synthesis, Purification and quality control of peptide based radiopharmaceuticals  $^{68}\text{Ga}$ - DOTATOC,  $^{68}\text{Ga}$ -PSMA,  $^{68}\text{Ga}$ -RGD,  $^{68}\text{Ga}$ -Excedrin  
Synthesis, Purification and quality control of radiopharmaceuticals like  $^{68}\text{Ga}$ -Zoledronate,  $^{68}\text{Ga}$ -MAA,  $^{68}\text{Ga}$ -EDTA
- **Therapeutic radiopharmaceuticals**  
Synthesis, Purification and quality control of peptide based radiopharmaceuticals  $^{177}\text{Lu}$ - DOTATOC,  $^{177}\text{Lu}$ -PSMA,  
Synthesis, Purification and quality control of Monoclonal antibody and other biomolecule based radiopharmaceuticals  $^{177}\text{Lu}$ -Trastuzumab,  $^{131}\text{I}$ - Rituximab

### ***Course Outcomes:***

- Understand and strengthen concepts radio-chemistry and radio-pharmacy
- Learn and perform the various synthesis and quality control of radiopharmaceuticals

## **NMMMI405:Therapeutic Nuclear Medicine & Radiation Dosimetry (40 Hours)**

**Coordinators: Mr. Ashish Kumar Jha**  
**ashish.kumar.jha.77@gmail.com**

### ***Course Details:***

- **Patient preparation, Facility preparation, Dosimetry planning, administration of radionuclide and patient monitoring in radionuclide therapy**
  - I-131 low dose Therapy I-131 High dose Therapy I-131 MIBG Therapy
  - Lu-177 DOTATATE Therapy Y-90 DOTATATE Therapy Bi-213 DOTATATE Therapy Lu-177 PSMA Therapy
  - Ac-225 PSMA Therapy Bi-213 PSMA Therapy
  - Trans Arterial Radio Embolisation (TARE) Bone pain palliation therapy
  
- **Dosimetry:**
  - Post therapy imaging Dosimetry scan
  - Pre and post therapeutic dosimetry using various software Dosimetry in TARE procedure

### ***Course Outcomes:***

- Understand and strengthen concepts therapeutic nuclear medicine and dosimetry
- Learn and perform the various aspects of radionuclide therapy and dosimetry

**NMMMI 406: Project: Medical Physics or Radiochemistry/Radio-pharmacy (80 Hours)**

**Coordinators: Mr. Ashish Kumar Jha  
ashish.kumar.jha.77@gmail.com**

***Course Details:***

- Students will be assigned a project at the start of their second year, focusing on either Medical Physics or Radiochemistry/Radiopharmacy. They have to perform the experiments and write a thesis

***Course Outcomes:***

- Understand and strengthen concepts research methodology, research protocols
- Learn and perform the scientific project and write a scientific thesis

## Grand Viva: Clinical Applications of Medical physics, Radiochemistry and Technology (80 Hours)

### Course Details:

- Students will be posted in the nuclear medicine department to gain practical experience in nuclear medicine physics, radiochemistry, and clinical technology. This practical knowledge will be evaluated through a grand viva examination.

### Course Outcomes:

- Understand and strengthen basic and advanced concepts of nuclear medicine physics, radiochemistry and technology

### Reference Books:

- |   |                                    |
|---|------------------------------------|
| 1. Gray's Anatomy for Students                      | Richard L Drake, Vogl and Mitchell |
| 2. Principles of Anatomy and Physiology             | Tortora and Derrickson             |
| 3. Human Anatomy (Vol I,II, III)                    | B D Chaurasia                      |
| 4. Cell & Molecular Biology                         | De Robertis                        |
| 5. Molecular Biology of the Cell                    | Alberts, Bray, Lewis, Raff         |
| 6. Cell Signaling                                   | Morgan                             |
| 7. Molecular Biology of Gene                        | Watson                             |
| 8. Genes V  | Benzamin                           |
| 9. Biochemistry                                     | Lehninger                          |
| 10. Biochemistry, 4th ed. (WH freeman and company)  | Lubert Stryer                      |
| 11. Recombinant DNA                                 | Tooze, Tustz                       |
| 12. Basic Medical Biochemistry                      | Smith Marks & Libermann            |
| 13. Biochemistry                                    | Harper                             |
| 14. Text Book of Microbiology                       | Panikar                            |
| 15. Physics in Nuclear Medicine                     | Cherry, Sorenson, Phelps           |
| 16. The essential Physics of Medical Imaging        | Bushberg, Seibert, Leidholdt       |
| 17. Medical Imaging Physics (Wiley-Liss )           | Hendee & Ritenour                  |
| 18. Introduction to Medical Physics                 | Arid                               |
| 19. Medical Physics                                 | Cameron                            |
| 20. Advances in Diagnostic Medical Physics          | Pant GS                            |
| 21. Quality Controls of NM Instrumentation          | Pant GS                            |
| 22. Radiation detection                             | Knoll                              |
| 23. Mathematical Models in Biology –An Introduction | Allman & Rhodes                    |
| 24. Introduction to Mathematical Physics            | C.Harper (Prentice Hall of India)  |
| 25. Field and Wave Electromagnetics                 | David Cheng                        |
| 26. Introduction to Mathematical Physics            | Michael T vaughn                   |
| 27. Numerical Methods for Engineers and Scientists  | Hoffman                            |
| 28. Numerical Methods for Engineers and Scientists  | Bajpai, I.M. Calcus & J.           |
| 29. Introductory Methods of Numerical Analysis      | S.S. Sastry                        |
| 30. Introduction to Mathematical Physics            | Michael T Vaughn                   |
| 31. Radiobiology for the radiologists               | Eric J Hall                        |
| 32. Physics and Radiobiology of Nuclear Medicine    | Gopal Saha                         |
| 33. Introduction to Radiation Biology               | B Uma Devi, Nagarathanam, Rao      |

34. Radiation Biology (Prentice Hall)	P.A. Casserette
35. Elements of Radiobiology	Selman
36. Physics and Radiobiology of Nuclear Medicine	Gopal B. Saha
37. Introduction to Health Physics Herman	Cember and Thomas Johnson
38. Radiation detection	Knoll
39. Handbook of Health Physics and Radiological Health	Shleien, Slaback, Birkey
40. Nuclear Physics (Narosa Pbl. House)	I. Kaplan
41. Nuclear Radiation Physics (Prentice Hall)	R.E. Lapp
42. Radiations from Radioactive Atoms (Govt. Print. Off.).	L. Slack & K. Way
43. Radiation Physics in Radiology (Springer).	R. Oliver
44. Field and Wave Electromagnetics (Addison-Wesley)	D.K. Cheng
45. Semiconductor Devices: Physics and Technology(Wiley)	S.M. Sze
46. Text Book of Medical Physiology	Guyton and Hall
Principles of Anatomy and Physiology (Wiley).	Tortora and Derrickson
48. Text Book of Human Histology with Colour Atlas	Inderbir Singh
49. Physiology	Chatterjee
50. The biology of Cancer	Robert A Weinberg
51. Introduction to Cancer Biology	Momna Hejmadi
52. Principles of Applied Biomedical Instrumentation	Geddes, Baker
53. Semiconductor Devices: Physics and Technology (Wiley).	S.M. Sze
54. Integrated Electronics (McGraw Hill).	Millman and Halkias
55. OPAMPS and Linear Integrated Circuits	Ramakant A. Gayakwad
54. Electronic Principles (McGraw Hill).	A.P. Malvino
55. Principles of Applied Biomedical Instrumentation (Wiley).	L.A. Geddes & L.E. Baker
58. Medical Imaging Physics (Wiley-Liss)	W.R.Hendee & E.R.Ritenour
Radiation Detectors and Instrumentation (Wiley).	Glenn F. Knoll
60. Techniques for Nuclear and Particle Physics experiments	W.R. Leo
61. Methods in Biostatistics	Mahajan
62. Methods of Biostatistics	Bhaskararao
63. Statistical and Mathematical Techniques in NM	GS Pant
64. Biostatistics: A foundation for the analysis in the Wayne W. Daniel:, John Wiley. Health Sciences	
65. Fundamental of Statistics Vol.-I & II	A.M.Goon, M.K.Gupta & B.Das
66. Essentials of Medical Statistics, Blackwell publishers	Betty Kirkwood
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