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Global GREEN
Regional BLUE
National ORANGE
Local (State) PINK

M.Sc. Nuclear Medicine Technology - Curriculum

GUIDELINES FOR COMPETENCY BASED POSTGRADUATE TRAINING PROGRAMME FOR M.Sc. IN NUCLEAR MEDICINE TECHNOLOGY

Program outcome

India is emerging as a super power in Health Care and Medical Research. Nuclear Medicine is integral part of modern-day holistic patient care. Nuclear medicine is a specialized area of radiology that uses very small amounts of radioactive materials, or radiopharmaceuticals, to examine organ function and structure. Nuclear medicine imaging is a combination of many different disciplines. These include chemistry, physics, mathematics, computer technology, and medicine. This branch of radiology is often used to help diagnose and treat abnormalities very early in the progression of a disease, such as thyroid cancer. Nuclear Medicine technologists play an important role in providing Nuclear Medicine services including therapy. The M.Sc. Nuclear Medicine Technology program is aimed to train a technician in the specialized field of Nuclear Medicine technology encompassing the entire spectrum of medical application of Nuclear Medicine. The trainee shall acquire skills in various aspects of theoretical, clinical and practical realms of Nuclear Medicine technology and enable the Nuclear Medicine Technology students to offer skill-based diagnostic, curative and preventive Nuclear Medicine technological support of the highest professional standards. The knowledge and attitudes imparted during the program shall enable the students to work as an independent technologist, teacher and researcher who is well versed with all technical aspect and research methodologies pertaining to Nuclear Medicine technology. Such an extensive training shall cater to the health care needs of patients of requiring Nuclear medicine therapy or diagnostic procedure at the local, regional and national levels and help deliver quality medical care of international standards to our population.

A student pursuing M.Sc. Nuclear Medicine technology course will acquire adequate knowledge related to

(a) Basic Sciences as applied to Nuclear Medicine so that the student is at par with national and international counterparts to help acquire focused and knowledge based understanding about the common and rare application related to different aspects of Nuclear Medicine.

(b) Technical, experimental, investigative and management issues applied to diagnostic and therapeutic aspects of Nuclear Medicine to gain comprehensive proficiency related to anatomy, physiology, and the diverse clinical spectrum of diseases relevant to nuclear Medicine application. The familiarity with local prevalent disease trends and management practices shall help the MSc Nuclear Medicine technology trainees serve their region, state, and country in a need-based and cost-effective manner.

(c) Awareness about recent advances in field of Nuclear Medicine technology with up to dated skill and knowledge to apply skill based intellectual decision based management

algorithms to benefit the region, state, and country. (d) Contribute to the field of Nuclear Medicine by imparting training to colleagues, teaching future students, and getting involved in research.

Eligibility Requirements:

A bachelor of science with Physics as a subject from a recognized University.

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SUBJECT SPECIFIC LEARNING OBJECTIVES

should A **During the M.Sc. program of M.Sc. Nuclear Medicine technology, a student will acquire:**

i. Technical, diagnostic, analytical, self-directed motivational learning with procedural skills required in care of patients with the full spectrum of diagnostic and therapeutic application of Nuclear Medicine, especially diseases which are prevalent in the region, state and country.
ii. Have comprehensive knowledge and skills in the areas of basic, technical and translational nuclear medicine to understand the disease burden, and epidemiology.
iii. Develop mentorship, leadership and networking skills to help teach, train and impart technical and research skills to future technologist in the state and country.
iv. Acquire skills to establish an effective communication network with the patients, patients' relatives, health administration, policy makers, common public, community leaders, peers medical fraternity and academicians in the field of Nuclear Medicine and allied fields.
v. Demonstrate a detailed and comprehensive understanding about the epidemiology, patho-physiology, diagnostic, management and preventive aspects of various diseases related to the entire spectrum of Nuclear Medicine in children and adults.
vi. Along with Nuclear Medicine Technology, should have skills in formulating research questions, planning, initiating and conducting translational, technical and epidemiologic research that prioritizes thrust areas of Nuclear Medicine Technology at institutional, state, national and international levels
vii. Should network to set up collaborative workforces at various levels to enhance the research milieu of the country with special focus on easing access to Nuclear Medicine procedures, lowering the cost of treatment modalities, novel indigenous modes of treatment and prevention aspects of different diseases.
viii. Demonstrate compassion for patients and their families and have an ethical and holistic approach to them to help deliver evidence-based, respectful ethical care to the patients.

The student is expected to gain knowledge in the following FOUR key areas:

A. Theoretical Knowledge:

i. The student will acquire knowledge in all aspects pertaining to the practice of Nuclear Medicine Technology with focus on Nuclear imaging and functioning in the region, state and country. This shall involve teaching and training to enable the student to provide technical support to the Nuclear Medicine care providers of the country. In addition to technical training, research skills shall also be prioritized so that the trainee gets the

skills to set up collaborative networking at institutional, state, national and global levels to add to the research milieu of the country.

ii. The M.Sc. Nuclear Medicine technology trainee shall acquire up-to-date knowledge, skills and attitudes in all technical aspect of Nuclear Medicine to understand the disease burden, epidemiology, patho-physiology and key determinants of various disease in the region, state and country.

iii. Shall be able to help in making patient-centric decisions based on the latest scientific advances in Nuclear medicine after rationally examining available data and apply these ethically in a cost-effective manner tailored to the needs of the patients of the region, state and country.

iv. Shall be well versed not only with technical aspect of diagnostic and therapeutic modalities related to diagnostic and therapeutic management, interventions, cutting edge research and their application to diverse aspects of Nuclear Medicine but shall also exposed to other related imaging modalities.

B. **Teaching skill:**

i. The student will be able to teach diverse aspects of Nuclear medicine technology to other technologists, junior colleagues, nursing and para-medical staff to enhance the skills of the work force at local level.

ii. Shall develop mentorship and leadership qualities to help teach, train and impart technical and research skills to future Nuclear Medicine technologist in the **state and country.**

C. **Research methodology:**

i. Shall have the skills to recognize knowledge gaps and unmet areas of need relevant to potential application of Nuclear Medicine of the local community.

ii. To seek solutions to such areas of unmet technical need, should be conversant with principles of research as applied to contemporary disease spectrum prevailing in the local community, state or country.

iii. Shall be trained to formulate, write and conduct research proposal using appropriate methodologies related to Nuclear Medicine in accordance with ethical guidelines

D. **Group approach:**

i. During the academic training, student will be part of multi-disciplinary meetings with specialists in Radiotherapy, Urology, Radiology, Nuclear Medicine departments and allied clinical disciplines.

ii. This will help them to understand the concept of team approach that seeks a multi-disciplinary approach in patient care. Inputs and insights gained during such interactions shall help in knowledge and skill building and is likely to improve patient outcomes of the region, state and country.

SUBJECT SPECIFIC COMPETENCIES

At the end of the course, the MSc Nuclear Medicine Technology student will acquire the following competencies under the following three domains:

(A) Cognitive domain (Knowledge domain):

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By the end of the course, the M.Sc. Nuclear Medicine Technology student should:

1. Have the ability to have a complete understanding about imaging and diagnostic procedures applied in Nuclear Medicine
2. Have a comprehensive awareness of normal processes that govern the human physiology and how they get impaired in disease states.
3. Demonstrate knowledge and expertise in relation to diagnostic and therapeutic applications and their adverse effects, short-term and long-term complications.
4. Have the skills to evaluate the suitability of investigations being performed and their cost-effectiveness suitable to the needs of the people of the region, state and country.
5. Ability to correctly analyze and interpret the results of various routine investigations so that appropriateness of adopted diagnostic or therapeutic modality may be evaluated.
6. The M.Sc. Nuclear Medicine Technology trainee should be able to sensibly and logically prioritize the investigations and treatment modalities for resource-limited situations commensurate with the requirements of the state or country so as to provide best possible treatment in all situations.
7. Be aware of different guidelines of various national and international associations and their applications tailor-made to suit the local needs of patients.
8. Should be conversant with the recent advances in science related to diagnostic and therapeutic application of Nuclear Medicine and allied subjects.
9. Have the ability to rationally analyze scientific data and apply to needs of the local populace of the state and country.
10. Have working understanding of biostatistics to enable balanced evaluation and analysis of literature.
11. Demonstrate competence in basic concepts of research design, methodology, clinical epidemiology and preventive issues of various common diseases relevant to Nuclear Medicine.
12. Should have the skills to conceptualize, write and conduct research proposal keeping in mind all ethical principles especially with context to Indian beliefs and customs, focusing on indigenous needs of local, regional, and national health priority.
13. Work towards helping establish low-cost diagnostic and treatment and rehabilitation related algorithms that can bring down the cost of various diagnostic and therapeutic application of Nuclear Medicine in the country.
14. Should have the ability to participate in establishment of a Nuclear Medicine facility, if required, even in remote areas of the region.
15. Should be able to identify, prioritize and assist in managing common emergencies encounter in Nuclear Medicine setup, prevalent in the region or state and take judicious decisions regarding urgent hospitalization to expedite care and/or other super-specialty referral, as required.
16. Have a basic understanding of digital applications in computers and use of Artificial intelligence and machine learning.

(B) Affective domain (Attitudes including Communication and Professionalism):

1. Demonstrate kindness, empathy and compassion towards all patients and their families
2. Treat all patients in a holistic manner
3. Respect the patients' right to information and second opinion.
4. Communicate well with patients and make all efforts to explain the rationale of diagnostic and treatment approach to patients and their caregivers in their own language for ease of understanding.
5. Spend time with patients explaining to them with thoughtfulness and empathy the pros and cons all options and further course of action.
6. Have the skills to participate in seminars, Continued Medical Education programs, panel discussions, lectures to discuss and review recent scientific data to further the cause of

Nuclear Medicine Technology in the country and increase visibility on national and global platforms.

7. Should have the ability to pass on such information and knowledge gained to other students and colleagues, especially those working in resource-limited settings to improve Nuclear Medicine services of the region, state and country.
8. Should actively cultivate skills to work in a team, with mutual respect, basic human courtesy and a supportive attitude towards others including other technicians, technical staff, policy makers and health administrators to improve Nuclear Medicine services at a regional, state and national level.
9. Develop a habit of maintaining honest, detailed and comprehensive medical records.
10. Maintain principles of etiquette and abide with the country's laws, adopting ethical practices at all times.
11. Be aware of ethical principles of clinical research as guided by institutional ethical committees.
12. Should demonstrate principles of equality when dealing with individuals of special groups.
13. Should be able to accept feedback and criticisms with an open mind.
14. As a skilled professional, be aware of the value of maintaining punctuality in clinical work.

(C) Psychomotor domain:

At the end of the course, the student should have acquired following skills:

1. Have the ability to have a complete understanding about imaging and diagnostic procedures applied in Nuclear Medicine.
2. Plan and execute the requisitioned procedure in a cost-effective manner tailored to the individual needs of the patients.
3. Be able to analyze correctly the results of all frequently used investigations necessary in Nuclear Medicine practice, including routine biochemistry, biomarkers, serological tests.
4. After having performed under supervision during MSc Nuclear medicine technology training, should be able to demonstrate requisite skills and confidence in independently using imaging modalities like:
    a. Single and multi-head gamma camera
    b. Various therapeutic and interventional procedures
    c. interpret of other physiological imaging studies

5. Have basic understanding about functioning of different equipments in routine use in the diagnostic and therapeutic Nuclear Medicine and knowledge about how to reduce their maintenance cost for the institution.
6. Have knowledge about Nuclear Medicine and its digital applications and fundamentals of use of artificial intelligence, machine learning and wearables in Nuclear Medicine.

Syllabus

Course contents:

I. Cognitive domain

Needs: Local : Pink, National : Orange, Regional: light blue, International : green

Topic wise teaching hours

1st Semester

PAPER 101(fundamentals of Radiation Physics)		
NMT101.1	Radiation Physics	10 hours
NMT101.2	Radiation Units	5 hours
NMT101.3	Radiation generators	10 hours
NMT101.4	Interaction of charged particle with matter	12 hours
NMT101 .5	Gas filled detectors & Semiconductor detectors	10 hours
NMT101.6	Scintillation detectors- Organic and Inorganic scintillation detectors	10 hours
NMT101.7	Liquid scintillation counters	8 hours
NMT101.8	General systems for operation and detection	5 hours
NMT101.9	Thermo luminescent Dosimeters & Autoradiography	8 hours
NMT101.10	Instruments for counting, gamma ray spectrometry	8 hours
NMT101.11	Whole body counting studies	5 hours
PAPER 102 (Human Anatomy & Physiology)		
NMT 104.1	Human cell	5 hours
NMT 104.2	Elementary tissues of human body	5 hours
NMT 104.3	Cardio Vascular System	5 hours
NMT 104.4	Hematology	5 hours
NMT 104.5	Lymphatic system	5 hours

NMT 104.6	Respiratory System	5 hours
NMT 104.7	Digestive System	5 hours
NMT 104.8	Urinary System	5 hours
NMT 104.9	Reproductive System	5 hours
NMT 104.10	Musculo skeletal System	10 hours
NMT 104.11	Eye & ENT	5 hours
NMT 104.12	Nervous System	10hours
NMT 104.13	Endocrine System	10 hours
NMT 104.14	Surface Anatomy & Surface Markings of Human Body	10 hours

PAPER 103

(MEDICAL ETHICS AND GENERAL PRINCIPLES OF HOSPITAL PRACTICE AND CARE OF PATIENT)

NMT 103.1	Ethical Theories	45hour
NMT 103.2	General principles of hospital practice and care of patient	45hour

2nd Semester

PAPER 104

(RADIOISOTOPE APPLICATIONS AND RADIATION SAFETY)

NMT104.1	Bio-medical applications of radionuclides	40 hours
NMT104.2	Radiation protection	30 hours
NMT104.3	Transport of radioactive material and designing of radiation laboratory	10 hours
NMT104.4	Stochastic and nonstochastic effects of radiation	10 hours

PAPER 105

(Fundamental of Biostatistics and Computer Application)

NMT 105.1	Numerical Methods	10 hours
NMT 105.2	Probability, Statistics and Errors	25 hours
NMT 105.3	Counting and medical statistics	12 hours
NMT 105.4	Computational Tools & Techniques	15 hours
NMT 105.5	Internet In NM, Telemedicine & Nanotechnology	15 hours

NMT 105.6	Internet In NM, Telemedicine & Nanotechnology	5 hours
NMT 105.7	Biomedical Ultrasound	10 hours
PAPER NMD106 (RADIATION BIOLOGY)		
NMT106.1	Radiation Biology	20 hours
NMT106.2	Radiation Chemistry	10 hours
NMT106.3	Radiation Effects on Major Organ Systems	20 hours
NMT106.4	Modification of radiation injury	10 hours
NMT106.5	Radionuclides in biology	10 hours
NMT106.6	Acute radiation effects	20 hours
3rd Semester		
PAPER 201 (NUCLEAR MEDICINE IMAGING AND COUNTING)		
NMT 201.1	Rectilinear scanner and Photography	15 hours
NMT 201.2	Gamma Camera	20 hours
NMT 201.3	SPECT (Single photon emission computerized tomography)	10 hours
NMT 201.4	Probe Systems	9 hours
NMT 201.5	Dose calibrator	8 hours
NMT 201.6	Instruments in Radiation Safety	8 hours
NMT 201.7	Practical	20 hours
PAPER 202 (PRINCIPLES AND PRACTICE OF RADIOLOGICAL PROTECTION)		
NMT 202.1	General principles of radiation protection	20 hours
NMT 202.2	Radioactive decontamination and waste disposal	10 hours
NMT 202.3	Regulatory Aspects & Licensing	25 hours
NMT 202.4	Transportation of radioactive substances	20 hours
NMT 202.5	Practical	20 hours
PAPER 203 (PET CYCLOTRON AND ALLIED INSTRUMENTATION)		
NMT 203.1	Cyclotron	10 hours
NMT 203.2	Positron Emission	10 hours

	Tomography	
NMT 203.3	Computed Tomography	8 hours
NMT 203.4	MR/CT/Ultrasound imaging	8 hours
NMT 203.5	Fusion imaging	10 hours
NMT 203.6	Basic Molecular Imaging	15 hours
NMT 203.7	Diagnostic Radiology	20 hours
NMT 203.8	Practical's	25 hours

4th Semester

PAPER 204

(PRINCIPLES AND PRACTICE OF RADIOPHARMACY)

NMT204.1	Regulatory Constraints	5 hours
NMT204.2	Radionuclide production and characteristics	15 hours
NMT204.3	Introduction to Radiopharmacy	15 hours
NMT204.4	Production of medically useful radioisotopes in Cyclotron	5 hours
NMT204.5	PET isotopes	7 hours
NMT204.6	SPECT isotopes	5 hours
NMT204.7	Therapeutic isotopes	5 hours
NMT204.8	Characteristics of Specific SPECT radiopharmaceuticals	10 hours
NMT204.9	Characteristics of PET radiopharmaceuticals	10 hours
NMT204.10	Quality control of radiopharmaceuticals	8 hours
NMT204.11	Practical	15 hours

PAPER 205

(NUCLEAR MEADICINE THERAPY AND RECENT ADVANCES)

NMT205.1	Therapeutic applications of Radionuclides	10 hours
NMT205.2	I-131 Low dose Therapy	7 hours
NMT205.3	I-131 high dose Therapy	7 hours
NMT205.4	Trans arterial radioembolization	7 hours
NMT205.5	Radiation Dosimetry	8 hours
NMT205.6	Potential Exposure and Emergency Plans	5 hours
NMT205.7	Transportation of PET Radiopharmaceuticals	3 hours
NMT205.8	Design of Radiation Centers	5 hours
NMT205.9	Diagnostic In-Vivo Techniques	15 hours

NMT205.10	Lung imaging studies	5 hours
NMT205.11	Cardiac studies	5 hours
NMT205.12	Central nervous study	3 hours
NMT205.13	Bone marrow	2 hours
NMT205.14	Miscellaneous studies	2 hours
NMT205.15	Patient Care and Hospital practice	2 hours
NMT205.16	Practical	5 hours
NMT205.17	Practical's	5 hours

COURSE PLAN OF M.Sc. NUCLEAR MEDICINE TECHNOLOGY(NMT)

- **Details of theory & practical subjects and allotted hours are as detailed here under**
- **Table: Teaching subjects & distribution of teaching hours in respective Semester**

	SEMESTER 1		
NMT 101	**Fundamentals of Radiation Physics**	**91**	**80 + 20**
NMT 102	**Human Anatomy and Physiology**	**90**	**80 + 20**
NMT 103	**Medical ethics and general principles of hospital practice and care of patient**	**90**	**80 + 20**
	Practical (Experiment+Viva)		**40 + 60**
	Total		**400**
	SEMESTER 2		
NMT 104	**Radioisotope applications and radiation safety**	**90**	**80 + 20**
NMT 105	**Fundamental of Biostatistics and Computer Application**	**92**	**80 + 20**
NMT 106	**Radiation Biology**	**95**	**80 + 20**
	Practical (Experiment+Viva)		**40 + 60**
	Total		**400**

	SEMESTER 3		
NMT 201	**Nuclear medicine imaging and counting**	**90**	**80 + 20**
NMT 202	**Principles and practice of radiological protection**	**95**	**80 + 20**
NMT 203	**Pet cyclotron and allied instrumentation**	**96**	**80 + 20**
	Practical 3(Experiment+Viva)		**40 + 60**
	Total		**400**
	SEMESTER 4		
NMT 204	**Principles and practice of radiopharmacy**	**100**	**80 + 20**
NMT 205	**Nuclear meadicine therapy and recent advances**	**105**	**80 + 20**
NMT 206	**Dissertation (Thesis, Record, viva Voice)**		**50 + 50**
	Total		**300**

- **There will be two section in NMD102(structural and functional anatomy) and NMD105(Fundamental of Biostatistics and computer application) ,section A and section B. Each section will contain 50-50 marks**
- **NMD102(Human Anatomy and Physiology) = Section A(Anatomy) and Section B(physiology)**
- **NMD105(Fundamental of Biostatistics and Computer Application)= Section A (Biostatistics) and Section B(Computer Application)**

A. Basic Sciences as applied to Nuclear Medicine

1. History of Nuclear Medicine and Foundations of Nuclear Medicine
2. General principles of Preventive and Rehabilitative Nuclear Medicine
3. Primordial, Primary and Secondary Prevention in Nuclear Medicine
4. Basics of Radiation Physics and Radiation Units
5. General principle of Gas filled detector, Semiconductor detector, Scintillation Detector, Neutron detector and Well counter in Nuclear Medicine.
6. Principle, and working of Radiation generator in Nuclear Medicine.
7. Interaction of charged particle with matter, Photoelectric effect, Compton

effect,

Pair production Annihilation in Nuclear Medicine.

8. Principle and Working of TLD in Nuclear Medicine.
9. Principle of Autoradiography in Nuclear Medicine.
10. Instruments for counting, gamma ray spectrometry in Nuclear Medicine.
11. Whole body counting: principles of whole body counting, design of whole bodycounting system, stationary systems, single and multiple crystal systems in Nuclear Medicine.

B. Introduction of basic Clinical Application of Nuclear Medicine Technology

1. Thyroid radioactive uptake measurements, ^{131}**I** therapy for treatment of hyperthyroidism, thyroid follicular carcinoma.
2. ^{99m}**Tc** applications in medical imaging of different organs and dynamic /function studies
3. ^{18}**FDG** in brain, heart and tumor imaging Radionuclide in therapy
4. ^{186}Re-HEDP, ^{153}Sm-EDTMP, lutetium-177-PSMA. DOTA, Ac-base radionuclide therapy
5. Storage and transport of waste, transport index. Classification of radiation labs, design of areas for radioisotope laboratories, criteria for grading laboratories using unsealed radioisotopes
6. Imaging of various system such as Thyroid, Liver, Brain, Bone, kidney.
7. Thyroid function studies and therapy of Thyroid disorders.
8. Investigation of central nervous system
9. Evaluation of Renal perfusion and function
10. In-vitro studies like RIA, GFR Estimation.
11. Diagnosis and follow up of urinary tract obstruction.
12. Pulmonary Emboli, split function.
13. Cardiac perfusion, viability, infraction, LVEF.
14. Skeleton tumor, infection
15. Neuro imaging Dementia, movement disorders, tumor seizure and brain death.
16. Acquisition of Lymphoscintigraphy, Salivary gland scintigraphy, Gastric emptying, Hepatobiliary.
17. ^{32}**P** applications in polycythemia vera and leukemia
18. ^{51}**Cr** labeling with red blood cells.
19. ^{58}**Co**/ ^{57}**Co**: Applications in schilling's test of vitamin B12 absorption, double tracer technique and whole body counting
20. ^{60}**Co**: in cancer treatment, gamma knife
21. Decontamination of person, decontamination of room Radio isotopic waste, general principles, liquid and solid waste, disposal of solid, liquid and gaseous effluents/ waste.

C. Laboratory testing: outlining use of Diagnostic and Imaging Modalities in the domain of Nuclear Medicine and Correlative imaging.

1. Nuclear medicine and applications in Cardiology
2. Clinical applications of Cardiac MRI, CT and PET imaging
3. Principles of coronary angiography and functional coronary imaging

4. Principles of quality control and quality assurance
5. Principle of Scintillation detector, Semiconductor detector Gas filled detector.
6. Clinical application of PET-CT and SPECT
7. Principle of Well counter
8. Principle of dosimetry
9. Calibration of equipment using phantom
10. Principle and working of cyclotron
11. Principle and working of various type of radionuclide generators.
12. Any other related areas.

D. Fundamental of Biostatistics and Computer Application

1. Numerical Methods
2. Probability, Statistics and Errors
3. Counting and medical statistics
4. Computational Tools & Techniques
5. Internet In NM, Telemedicine & Nanotechnology
6. Pulse shaping oscillators, regulators, PM tubes, preamplifiers, pulse height analyzers, SCA, MCA, coincidence & anti coincidence circuits, equivalent circuits.

E. Human Anatomy & Physiology relevant to Nuclear Medicine

1. General structure of the human body, anatomic terminology, planes of section-Structure and function of normal human cell.
2. Elementary tissues of human body Epithelial tissue, muscular tissue, connective tissues and nervous tissue.
3. Cardio Vascular System - Anatomy of heart and functions
4. Hematology-Composition of Blood - functions of blood elements –Blood Group and coagulation of blood, disorders of blood.
5. Lymphatic system - Name and function of lymph glands, Lymphatics and Lymphatic pathway outline.
6. Respiratory System: various parts of respiratory system and their functions, Anatomy of upper respiratory tract, Structure and functions of lungs, Anatomy of bronchial tree, Physiology of Respiration.
7. Digestive System – Structure and function of various component of digestive system. Physiology of digestion and food components.
8. Urinary System: various parts of urinary system and its function-structure and function of kidneys
9. Reproductive System: physiology and anatomy of Male & Female
10. Eye,&ENT: Anatomy and physiology of eye, ear and nose.
11. Nervous System various parts of nervous system
12. Endocrine System: Endocrine glands, their hormones and functions-Thyroid, Parathyroid, Suprarenal, Pituitary, pituitary and Thymus)
13. Surface Anatomy & Surface Markings of Human Body.
14. Musculoskeletal System: Classification of bones & joints, structure of skeleton

F. <u>Recent Advances:</u>

i. Quantification in PET imaging
ii. Automated whole body lesion detection for multiple myeloma on Ga-68 pentixa for PET/CT imaging using deep learning method
iii. Review of recent literature and guidelines

iv. Advances in Nuclear medicine technology
v. Artificial Intelligence, Machine learning
vi. Whole body PET-CT simulation, wholebody PET MRI and multimodal molecular imaging system.
vii. Spectral unmixing imaging for differentiating brown adipose tissue mass and its activation.
viii. Study of the influence of age in F-18 FDG PET images using a data driven approach and its evaluation in Alzheimer's disease
ix. Any other related areas.

II. Psychomotor domain:

Technical aspects of clinical application in Nuclear Medicine common and uncommon communicable and noncommunicable life style diseases

i. Detection, evaluation and management of complications of GFR Estimation, Esophageal transit time, Gastric emptying time, Renal transplant evaluation, Determination of Ejection Fraction.
ii. Pre-operative evaluation and management of patients.
iii. Evaluation and management of non-critically ill hospitalized patients.
iv. Counselling and education of patients , physical activity, blood pressure monitoring, short term and long term targets of disease control and screening for sequelae and complication.
v. Detection of contamination in various work places.
vi. Characterization of unknown isotopes.
vii. Practical aspects of setting up an integrated nuclear medicine health care system.
viii. Management of accidental spillage.
ix. Chronic care of different diseases in the community
x. Clinical Trials in Nuclear medicine, Statistical and Ethical Considerations, in Trials, Approaches to Clinical Trial Design and Methodologies.
xi. Prevention diagnosis and treatment of health condition in particular non communicable diseases such as cancer, cardiovascular diseases.
xii. IAEA aim is help build member states capacities to support them in establishing high quality health care worldwide.
xiii. Non communicable diseases are the leading cause of death and disease burden globally, cardiovascular disease account for the major part of death related to non-communicable disease followed by different type of cancer COPD and diabetes.

1. **Technical aspects of clinical care including the following aspects of nuclear imaging in adults and children including but not limited to:**

i. Evaluation and management of patients with renal disorder. acute kidney disease, non-invasive and invasive hemodynamic evaluation and monitoring
ii. Neuro-endocrine Signaling Systems
iii. Functional cardiology and its application in nuclear medicine

iv. Risk factor for malignancy and its evaluation

Besides the above, science graduate students in M.Sc.(Nuclear Medicine Technology) should be involved in nuclear imaging, didactic and self-learning schedules assigned to them.

The Objectives of the 2 year training program is to train the science graduate as a best skilled Nuclear medicine Technologist in different aspects of theoretical, clinical and practical spheres of Nuclear Medicine standards and enable them to offer skill based imaging, curative and preventive care with the highest professional

Radiation Protection	Quantities used in radiation protection, Justification of practice, optimization of protection and Individual dose and risk limits, regulatory aspects of radiological safety, Control of internal and external hazards. Principles of radiation protection, specific factors involved in radiation protection time, distance, shielding. Quantities and units: Dose, roentgen unit of exposure, radiation sensitivity of biological materials, radiation absorbed dose (RAD, Gray), radiation weighting factor , Relative biological effectiveness (RBE), Quality factors, Roentgen Equivalent man (REM), Sievert , equivalent dose , effective dose, collective equivalent dose, total effective dose equivalent, radiation dose limits, maximum permissible doses(IRCP recommendations) Natural radiation exposure, cosmic radiation, terrestrial radiation , nuclear fall outs, medical exposures. Basis for exposure limits for occupational exposure, ALARA, exposure of embryo /fetus younger persons, occupational exposures, members of the public, dose limits for patients, risks associated with recommended limits. Deterministic and stochastic effects, the concept of comparative risk. Dos and Don'ts in radiation protection practice. Personal monitoring, film badges, TLD badge, use of survey meters and dose calibrators, use of dose constraints for staff and pregnant women. ICRP and National radiation safety standards.
Radiopharmacy	General physicochemical properties of radioactive compounds: distinction between radionuclide, radiochemical and radiopharmaceuticals, carrier concept (carrier-free, carrier added, no carrier added). definition of a Radiopharmaceutical, ideal Radiopharmaceutical, Important characteristics of a radionuclide to be used in imaging and therapy, with example of 68Ga, 177Lu, 90Y, 18F, 99mTc, 131I, 125I etc., availability, short effective half-Life, particle emission, decay by electron capture or isomeric transition. Chemistry of tracer radionuclide metals: hydrolysis, reduction-oxidation, concentration methods, radiolytic decomposition High target to non-target activity ratio Isotope exchange reactions. Introduction of a foreign label. Bifunctional chelating agents. Biosynthesis. Efficiency and stability. The isotopic effect. Radiolysis. The importance of technetium. Oxidation states of technetium. Complexes with metal-nitrogen bonds. Oxo-complexes. Technetium complexes with low oxidation states. Radioisotopes of iodine: specific characteristics of 123I, 124I, 125I and 131I. Isotopic exchange, electrophilic substitution, nucleophilic substitution. Quality control protocols. Beta. Gamma, alpha and auger-electron emitting radio nuclides and their radiopharmaceuticals Radiolabeling, technetium coupling with biologically active modules. Precursors and chelating agents needed for the labelling of Biomolecules, cellular labeling with 99mTc chelates.
Nuclear Imaging	Nuclear medicine imaging is a method of acquiring images by detecting radiation from different parts of the body after a radioactive tracer is given to the patient. The images are digitally generated on a computer and transferred to a nuclear medicine physician, who interprets the images to make a diagnosis. Radioactive tracers used in nuclear medicine are, in most cases, injected into a vein. For some studies, they may be given by mouth. These tracers aren't dyes or medicines, and they have no side effects. The amount of radiation a patient receives

	in a typical nuclear medicine scan tends to be very low. Nuclear imaging is used primarily to diagnose or treat illnesses. Conditions diagnosed by nuclear medicine imaging include: • Blood disorders. • Thyroid disease, including hypothyroidism. • Heart disease. • Gallbladder disease. • Lung problems. • Bone problems, including infections or breaks. • Kidney disease, including infections, scars or blockages. • Cancer. Nuclear medicine imaging can also be used to treat conditions or to evaluate how treatment is working.
Radiation Biology	Radiation effects on Cell: membrane, energy metabolism, synthetic processes, chromosomes, chromosomal type aberrations, chromatid type aberrations, sub chromatid aberrations, relation between aberration structure and the mitotic and meiotic cycles. Radiation effects on cell division. Radiation Molecular Biology: radiation effects on proteins, nucleic acids, carbohydrates, lipids, polymerases, transferases, isomerases and anti-oxidative enzymes. Radiation and independent cell systems: target theory, multitarget theory, target size, multi hit theory, multitarget multi hit theory. Differential cell response: Criteria of radiosensitivity, factors affecting sensitivity, average interphase chromosomal volume, ploidy, nuclear factors, cytoplasmic factors, categories of mammalian cell sensitivity, specific classifications of mammalian cell sensitivity.

TEACHING AND LEARNING METHODS

General principles:

The basic aim of postgraduate technical training and education is to produce technologist who understand the needs of community health of the state and country and enhance the quality of health care as well as provide an impetus to research, education, and training of the medical community. The postgraduate students after completion of the skill based competency training programme should be able to successfully address the technical aspects of medical requirements of the community. Learning during the programme is not only goal-oriented and didactic but also essentially self-directed and emanates from technical and academic work. The designated academic sessions are meant to supplement the student's core efforts.

Teaching Methodology:

The student shall be given the responsibility of managing and caring for patients in a gradual and phased manner under supervision, after the student demonstrates skill and efficiency at each step. Teaching sessions shall be an overall judicious amalgamation of case presentations, journal clubs, seminars, group discussion related to non-invasive and invasive lab data, focused brief topic presentations as allotted from time to time, case-based learning, integrated and interdepartmental meetings including any other collaborative activity with allied departments, as deemed necessary. Suggested modalities of teaching-learning methods are summarized below but shall not be limited to these. The frequency of the mentioned teaching and learning methods may vary based on perceived requirements, candidates' competencies, work load and overall working schedule. Self-directed motivational learning

forms a key part of the training for which although the hours are not specifically ear-marked, but it shall be integrated into day to day learning.

Formal teaching sessions:
These include regular bedside case presentations and demonstrations, didactic lectures, journal clubs, seminars, interdepartmental meetings. This will comprise of the following:

Academic sessions

- Clinical case discussion - once a week
- Journal club - once a week
- Seminar - once a week
- Student project presentation - twice a week

All above may refer to sessions conducted in given Department and not for each trainee.

Didactic Lectures:

In addition, 10 lectures per year covering recent advances in all aspects of cardiac, renal, bone, thyroid, parathyroid, GE, hepatobiliary, lymphoscintigraphy, would be taken by faculty members. All students are required to attend these lectures. Short term basic and clinical courses on:

- Bio-statistics
- Research methodology and experimental lab medicine relevant to Nuclear Medicine
- Use of digital applications, artificial intelligence and machine learning in Nuclear Medicine.
- Bioethics and ethical issues in Nuclear Medicine

- Each student is encouraged to attend accredited scientific meetings (symposia, NMPAI conferences, SNMICON conference) at least once or twice a year.
- Sessions on Research methodology, experimental methods relevant to the Nuclear Medicine specialty, digital application and use of computers and artificial intelligence in Nuclear Medicine, Biostatistics, pertinent ethical and legal issues in Nuclear Medicine practice including teaching methodologies, hospital waste management, health sanitation, health economics, are additionally suggested.

- **Log Book:** During the training period, the M.Sc. Nuclear Medicine Technology student shall maintain a detailed and comprehensive Log Book indicating the duration of the postings and work done in Nuclear Medicine Wards, OPDs, Non-invasive and invasive labs. Data should include the procedures assisted and performed, and teaching sessions attended. The purpose of the Log Book is to:
  a) Maintain a record of the work profile during training,
  b) Enable Consultants to access information about the work of the student
  c) Keep an eye on the progress and intervene if and when necessary
  d) As a means to assess from time to time, the experience gained and quality of work performed by the student.

The Log Book shall also serve as a source to help in the internal evaluation of the M.Sc. student trainee. The Log book shall be cross-checked and assessed periodically by the faculty members who are involved in imparting the training. It shall be signed by the Head of the Department and a proficiency certificate from the Head of

Department regarding the student's technical competence, overall skillful performance of procedures and general approach towards patients will be necessary before the student is allowed to appear in the final examination.

- The Department shall encourage e-learning activities.
- Clinical postings: Recommended schedule for two years training

Each student will undergo the following rotations in various clinical areas of Nuclear Medicine during the two years of training.

i. Nuclear Medicine Ward
ii. Gamma Camera
iii. Elution
iv. GFR Lab
v. PET Imaging
vi. PET Pharmacy
vii. Cyclotron
viii. Radiation Safety and Radiation Protection

Thesis:

Each student is required to undertake dissertation under the guidance and mentorship of a faculty member. The M.Sc. Nuclear Medicine Technology student is required to submit a thesis protocol after due advice and approval from the faculty guide within 18 months after joining the course. In addition, the student will also participate in various departmental research activities from time to time.

During the training program, patient safety is of paramount importance; therefore, skills are to be learnt and performed initially under supervision followed by performing independently in a phased and guided manner. For this purpose, documentation of proficiency of skills is mandatory.

Recommended Reading:

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Name of Book	Editor's Name
• Cell & Molecular Biology	De Robertis
• Molecular Biology of the Cell	Alberts, Bray, Lewis, Raff
• Molecular Biology of Gene	Watson
• Gene –V	Benzamin
• Cell Signaling	Morgan
• Recombinant DNA	Tooze, Tustz
• Text Book of Medical Physiology	Guyton
• Physiology	Chatterjee
• Biochemistry	Lehninger
• Biochemistry	Stryer
• Basic Medical Biochemistry	Smith Marks & Libermann
• Biochemistry	Harper
• Text Book of Microbiology	Panikar
• Methods in Biostatistics	Mahajan
• Methods of Biostatistics	Bhaskararao
• Statistical and Mathematical Techniques in NM	GS Pant
• Fundamental of Statistics Vol. I & II	A.M. Goon, M.K. Gupta & B. Das

• Essentials of Medical Statistics, Blackwell publishers	Betty Kirkwood
• Object Oriented Programming with C++	E. Balaguruswamy.
• A First Course in Computers	Sanjay Saxena.
• Calculus (Pearson Education, 2003)	G.B. Thomas and R.L. Finney
• Introduction to Mathematical Physics	C. Harper (Prentice Hall of India)
• Field and Wave Electromagnetics	David Cheng
• Principles of Applied Biomedical Instrumentation	Geddes, Baker
• Mathematical Models in Biology –An Introduction	Allman & Rhodes
• Radiation detection	Knoll
• Handbook of Health Physics and Radiological Health	Shleien, Slaback, Birkey
• Physics and Radiobiology of Nuclear Medicine	Gopal Saha
• Radiation Biology	Casarett
• Elements of Radiobiology	Selman
• The essential Physics of Medical Imaging	Bushberg, Seibert, Leidholdt
• Physics in Nuclear Medicine	Cherry, Sorenson, Phelps
• Medical Imaging Physics	William R.Hendee
• Introduction to Medical Physics	Arid
• Medical Physics	Cameron
• Advances in Diagnostic Medical Physics	Pant GS
• Quality Controls of NM Instrumentation	Pant GS
• Quality Control in NM, Radiopharmaceutical,	Rhodes Buek
• Radiation Safety for unsealed Sources	Pant GS
• Radiation Dosimetry	Attix, Poesch
• Fundamentals of Nuclear Pharmacy	Gopal Saha
• Radiopharmaceuticals	Gopal Subramaniam
• Text Book of Radiopharamcy	Sampson
• Radio immunoassay Principles & Practices	Pillai & Bhandarkar
• Nuclear Medicine in Vitro	B. Rothfield
• Principles of Nuclear Medicine	Henry N. Wagner (Jr.)
• Nuclear Medicine Technology and Techniques	Bernier, Christian, Langan
• Principles & Practice of Nuclear Medicine	Early & Sodee
• Basics of PET Imaging	Gopal Saha
• PET and PET/CT in Oncology	Pehr, Biersack, Coleman
• Nuclear & PET Techniques	Christian
• Interventions in Nuclear Medicine	Richard P. Spencer
• An Atlas of Clinical Nuclear Medicine	Fogelman & Maisey
• Clinical SPECT Imaging	Elissa Lipcon Kramer

Journals:

International journal of radiation application instrumentation-part B
- Nuclear Medicine and Biology
- Medical Physics
- Journal of Nuclear Medicine Technology
- Journal of Nuclear Medicine
- European Journal of Nuclear Medicine
- Seminars in Nuclear Medicine
- Nuclear Medicine Annual
- World Journal of Nuclear Medicine
- Annals of Nuclear Medicine
- Indian Journal of Nuclear Medicine
- Hellenic Journal of Nuclear Medicine

E-learning resources:

1. https://www.iaea.org/online-courses

2. https://www.snmmi.org/
3. https://www.springer.com/journal/259
4. https://www.radiologyinfo.org/en/info/gennuclear
5. https://www.eanm.org/