

## **M.Sc. NUCLEAR MEDICIN TECHNOLOGY SYLLABUS**

### **First Year**

#### **Paper :1: Principles of Epidemiology, Research Methodology, Biostatistics and Medical Ethics :-**

##### **UNIT I: EPIDEMIOLOGY**

Introduction: Historical aspects and evolution of epidemiology, definitions and concepts in Epidemiology.

Natural history of disease. Approaches in Epidemiology. Descriptive and Analytical Epidemiology, Disease burden and Measures of risk and death. Epidemiological Investigations.

##### **UNIT-II – RESEARCH METHODOLOGY**

Principles of Research study designs, Sampling Methods, Sample size Estimation, Protocol writing and Measures of Association.

Introduction to Operations Research.

##### **UNIT III: BIOSTATISTICS**

Fundamentals of Biostatistics: Introduction, Types of data, Tabular and graphical presentation of data. Measures of location, dispersion and correlation: Measures of central tendency. Mean, mode, median, GM, HM, quartiles Measures of dispersion— Range, Standard Deviation, Variance, Coefficient of Variation.

Probability and statistical inference: Concept and probability distribution. Normal distribution— density curves, applications and statistical tables. Concept of significance tests, parametric and nonparametric tests, standard error and confidence intervals.

Inferential statistics: Probability and distributions – Poisson, Binomial and Normal distribution – Chi-square test – Hypothesis test - Student's t-test – Correlation and Regression – ANOVA.

##### **UNIT IV: MEDICAL ETHICS**

Bioethics and Medical ethics: Historical perspectives & Introduction to Bioethics, Nuremberg Code, Declaration of Helsinki, Principle of essentiality, informed consent, confidentiality, minimisation of risk, accountability and responsibility. Ethics of clinical trials: Drug trials, vaccine trials, Clinical Trials with medical devices/surgical procedures/radioactive materials, Research in transplantation and stem cell therapy. Regulatory framework and guidelines for conduction of human research: Review processes, Institutional ethical committees, composition of committees, review procedures, WHO, UNESCO and ICMR guidelines.

## **References :**

- 1.** Epidemiology: An Introduction. Kenneth J. J. Rothman. Latest edition / Pub. Date: May 2002. Publisher: Oxford University Press.
- 2.** Epidemiology. Leon Gordis. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.
- 3.** Diseases and Human Evolution. Ethne Barnes. Latest edition / Latest edition / Pub. Date: March 2005. Publisher: University of New Mexico Press.
- 4.** Epidemiology: Beyond the Basics. F. Javier Nieto, Moyses Szklo. Latest edition / Pub. Date: November 2003. Publisher: Jones & Bartlett Publishers, Inc.
- 5.** Basic and Clinical Biostatistics. Beth Dawson, Robert G. Trapp, Robert Trapp. Latest edition / Pub. Date: March 2004.
- 6.** Discovering Statistics Using SPSS. Andy Field. Latest edition / Pub. Date: April 2005. Publisher: SAGE Publications.
- 7.** Arora PN & Malhon PK (1996). Biostatistics Imalaya Publishing House, Mumbai.
- 8.** Sokal & Rohlf (1973). Introduction to Biostatistics, Toppan Co. Japan.
- 9.** Stanton A & Clantz, Primer of Biostatistics — The McGraw Hill Inc., New York.
- 10.** Government of India. Good Clinical Practices for Clinical Research in India. New Delhi: 2001
- 11.** Indian Council of Medical Research. Ethical Guidelines for Biomedical Research on Human Subjects. New Delhi: 2000
- 12.** United Nations Educational, Scientific and Cultural Organisation (UNESCO). Universal Declaration on Bioethics and Human Rights. Paris; 2005

## **Paper II :**

### **1. Anatomy**

Musculo-skeletal system, Cardiovascular system, Respiratory system, Genitourinary system, Cerebro-vascular system, Alimentary system, Renal system, Central nervous system, Endocrinesystems.

### **2. Physiology**

Blood, Lymphatic channels, Digestive system, Cardiovascular system, Central Nervous system, Respiratory system, Endocrine system

### **3. Biochemistry**

Introduction to Biochemistry – Carbohydrates, Proteins, Enzymes, Lipids, Hormones and Vitamins, Nucleic acids.

Introduction to Immunology- humoral immune response, cell-mediated immune response, antigen-antibody interaction, monoclonal antibodies. Basic molecular biology

## **Paper III :**

### **1. Computers**

Basic aspects of computer structure and function, Applications of computer in nuclear medicine (Acquisition – static/dynamic/list mode/frame mode, processing the data and image processing), gamma camera – computer interface card and performance characteristics, uniformity correction circuits, LAN/WAN, Hub/switches, networking software, Internet browsers.

Personal computer-principals and application software for word processing, database, excel, power point and operating systems (DOS, UNIX). Introduction to computer programming in BASIC, C- Language, etc.

Internet in nuclear medicine : FTP, TCP/IP protocols, DICOM and interfile conversion software.

## **2. Fundamentals of Electricity & Electronics**

Circuit components – resistors, capacitors, inductors, transformers, Ohm's law, Circuit element –R, CR, LCR and LC networks

Basic Circuits- pulse amplifiers & pulse shaping oscillators, regulated power supply, SMPS power supply, RF power supplies, rectifiers, regulators, filter circuits, PM tubes, pre- amplifiers, pulse height analysers, SCA, MCA, coincidence & anti coincidence circuits, equivalent circuits.

Semiconductors: Conduction in crystals, energy band. Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, majority and minority carriers. p-n junction- properties forward and reversed bias, characteristics of p-n junction rectifiers- half wave and full wave, ripple factor, efficiency of Half wave and full wave rectifiers, filter circuits, Zener diodes.

Digital electronics – Boolean algebra, Gates, number systems, ADC/DAC, CRT. Transistor oscillators, Transistor as a switch - multivibrator–Monostable and Bistable multivibrators.

Special devices-SCR, Diac- Triac, Unijunction transistor (UJT), Field effect transistor (FET), Metal oxide field effect transistor (MOSFET). Simple ideas on operational amplifier.

Advance topics: Euclid's equation, Fourier Transforms, Modulation Transfer Function, Laplace transform, Sievert's integral, Numerical methods of integration, Digital filters.

## **Paper IV :**

### **1. Mathematics**

Functions and limits, Differentiation, Rules of differentiation, sum, difference, product and quotient formulae, function of a function rule, Differentiation of inverse trigonometric functions, parametric functions, Implicit functions, Logarithmic differentiation, Higher order derivatives and Partial differential integration, Methods of integration, Integration by substitution, Integration by parts, Definite integral and its properties. Differential equations, compartment analysis.

Vectors: Definition, Product of vectors, scalar and vector products, vector differentiation, Gradient, Divergence and curl.

Matrices system and Applications

Complex numbers: Definition, Modulus, Amplitude & properties, De Moivre's theorem, Extraction of roots of a complex number.

### **2. Statistics**

Probability – definition & laws; statistical models distribution – normal, binomial & Poisson, Measure of central tendency – mean, mode, median and standard deviation; Error of distribution – confidence limits test of significance, Z-Test, students-t test, F-

Test, chi-square, concept of correlation, regression line, curve fitting and least square fit, Analysis of variance.

Counting statistics – error propagation, limits of detectability, distribution of counting time, standard error, accuracy, figure of merit.

Specificity, sensitivity, accuracy and ROC

## **Paper V :**

### **1. Radiation Physics**

Basics of Atom, Radioactivity, Radioactive decay, Basics and operation of nuclear reactor and cyclotron. Interactions of radiation with matter and their importance in nuclear medicine.

Radiation detection and measurement :-

Gas filled detectors, Scintillation detectors, General systems for the scintillation detector. Liquid Scintillation detectors. Semi conductor detectors

### **2. Radiation Chemistry**

Atomic and molecular structure- bonding (electrovalent, covalent and *dative* bonds), valency, Atomic weight, molecular weight, solutions-normality, molarity of solution, acids and bases, hydrogen ion concentration, pH value, chemical reactions, solute, solvents, solubility, crystallisation, concept of chromatography and R<sub>f</sub>.

## **Paper VI :**

### **Radiation Biology**

General Biology, physiology, interaction of radiation with cells, mechanism of damage, nature of damage, factors modifying the damage, deterministic and stochastic effects of radiation, cancer risk estimation, damage to individual organs, prenatal effects of radiation, radiation protection standards.

## **Paper VII :**

### **Nuclear Medicine Instrumentation**

Gamma ray spectrometer, Probe systems, Nuclear gamma probe system with clinical applications, Rectilinear scanner, Focussed collimators- iso-response curve, focal length, depth of focus, effect of size and number of holes on response, septa thickness, resolution and sensitivity, line source response and MTF, Whole body counters – profile scanning and clinical applications.

## **Paper VIII :**

### **Radiopharmacy - Part I**

Production of radioisotopes - reactor produced, cyclotron produced, Radionuclide generators. Radionuclide generator system:  $^{99}\text{Mo}$ - $^{99\text{m}}\text{Tc}$  generator – solvent extraction, column generator, gel type generator;  $^{188}\text{W}$ - $^{188}\text{Re}$ ,  $^{113}\text{Sn}$ - $^{113\text{m}}\text{In}$ ,  $^{68}\text{Ge}$ - $^{68}\text{Ga}$ ; Ultra short-lived radionuclide generators:  $^{82}\text{Sr}$ - $^{82}\text{Rb}$ ,  $^{81}\text{Rb}$ - $^{81\text{m}}\text{Kr}$ ; Parent-daughter equilibrium.

Physical and chemical characteristics of radionuclides used in nuclear medicine, Criteria for selection of the radionuclides for diagnosis and therapy.

Chemistry of  $^{99\text{m}}\text{Tc}$ , labelling of commonly used cold kits- DTPA, GHA, DMSA, MAG3, MDP, phytates, ECD, EC, IDA compounds and S-colloid. Formulation of radiopharmaceuticals

PET Radiopharmacy and Radiochemistry, Synthesis modules to produce  $^{18}\text{F}$ FDG,  $^{11}\text{C}$ CO<sub>2</sub>,  $^{13}\text{N}$ H<sub>3</sub> and H<sub>2</sub><sup>15</sup>O

## **Paper IX :**

### **Clinical Nuclear Medicine Techniques – Part I**

Haematology studies- red-cell mass estimation, RBC survival and sequestration studies,  $^{51}\text{Cr}$  gastrointestinal blood pool loss study, plasma volume estimation using  $^{125}\text{I}$ -HAS and Ferrokinetic studies.

$^{67}\text{Ga}$  imaging, Lacrimal scintigraphic imaging, gastrointestinal protein loss estimation using  $^{51}\text{Cr}$ -chromic chloride, Lymphatic imaging, adrenal imaging using  $^{131}\text{I}$ -MIBG, Vitamin B<sub>12</sub> absorption study and Schilling Test, etc.

Diagnostic - In-vitro Techniques:

Principles of RIA, standard curve, data analysis, QC and applications. Methods of receptor assays, hormones, drugs, IRMA, ELISA. RIA estimation – T<sub>3</sub>, T<sub>4</sub>, TSH and thyroid antibodies, etc.

### **Practical / demonstrations:**

|    |                                                                              |
|----|------------------------------------------------------------------------------|
| 1. | Counting statistics.                                                         |
| 2. | Gamma ray spectrometry (EHT, gain, discriminator, etc.)                      |
| 3. | Gamma ray spectrometry- calibration, spectrum, energy resolution, linearity. |
| 4. | Spectrum of mixture of two isotopes and scatter fraction                     |
| 5. | Identification of unknown radionuclides.                                     |
| 6. | Liquid scintillation counting.                                               |
| 7. | Autoradiography                                                              |
| 8. | Radiation exposure: effect of distance, time & shielding                     |
| 9. | Photographic development.                                                    |

|     |                                                                                             |
|-----|---------------------------------------------------------------------------------------------|
| 10. | Dispensing of low dose from bulk supply                                                     |
| 11. | Calibration of pocket dosimeter and survey meter                                            |
| 12. | Study of energy dependence of a pocket dosimeter and a survey meter.                        |
| 13. | Thermal neutron attenuation in graphite, concrete and iron using a BF <sub>3</sub> counter. |
| 14  | Characteristics of different radiation.                                                     |
| 15  | Absorption and back-scatter of radiation.                                                   |
| 16. | Plateau of G.M. Counter.                                                                    |
| 17  | Dead time and resolving time of G.M. counter.                                               |
| 18  | Half value layer of gemitters and range of bemitters                                        |
| 19  | Half life of radioisotopes                                                                  |
| 20  | Resolution of half-lives from a mixture of radionuclides.                                   |
| 21  | Daughter- parent relationship of radioactive decay and radionuclides.                       |
| 22  | Efficiency of counting system.                                                              |

**\* IGCAR, Kalpakkam – 2 days field visit.**

**\* Practical (One day) – Common covering all Subjects**

## **Second Year**

### **Paper I :**

#### **Nuclear Medicine Instrumentation- Part II**

**Gamma Camera:** Basic principles of gamma camera, collimators - parallel hole, divergent, pinhole, fan beam, slant hole collimator. Gamma camera-computer interface- ADC/DAC. Criteria of installation of Gamma camera. Selection of gamma camera – specifications and other aspects.

**SPECT:** image reconstruction techniques, filters, artefacts in SPECT (attenuation correction, non-uniformity corrections, correction with combined SPECT-CT system), effect of scatter & scatter correction, partial volume effects, multi detector SPECT, coincidence, SPECT acquisition – step & shoot/continuous. SPECT v/s planar camera, SPECT v/s other modalities (CT, MRI, Ultrasonography}

**PET:** Historical developmental of Functional In Vivo Studies Using Positron, Physics and instrumentation in PET, Data acquisition and Performance Characterization in PET, Image reconstruction Algorithm in PET, Quantitative techniques in PET, Tracer Kinetic Modeling in PET, Co-registration of Structural and Functional images, Radiation Dosimetry and Protection in PET

**Medical Cyclotron:** Working principles of Cyclotron-Types of Cyclotron-Cyclotron generated radionuclides-Cyclotron layout & Approval-Shielding-Quality Control Procedures- production of  $^{18}\text{F}$ ,  $^{11}\text{C}$ ,  $^{13}\text{N}$ ,  $^{15}\text{O}$ .

## **Paper II**

### **Clinical Nuclear Medicine Techniques - Part II**

Renal imaging studies-diuretic renogram, Captopril renogram, standard renogram, uretic reflux study, renal transplant studies, static renal study.

Bone imaging: Routine bone (whole body and spot) imaging, bone flow study, quantitative bone scan-sacroiliac quantitative study, 3-phase bone scans.

Liver-spleen study, bone marrow imaging, spleen imaging with denatured RBC's

Gastrointestinal study- Hepatobiliary imaging, pancreas imaging, gastric oesophageal reflux, gastric emptying time, biliary reflux, Meckel's diverticulum imaging, GI bleeding with  $^{99m}\text{Tc}$ - RBC, Salivary gland imaging (static/dynamic), Gall bladder dynamic, dynamic studies using IDA compounds.

Lung imaging studies – ventilation lung imaging studies using gases ( $^{133}\text{Xe}$ ,  $^{81m}\text{Kr}$ ), Inhalation imaging using aerosols, aerosols generators, mucociliary clearance, COPD, Pulmonary permeability using DTPA, perfusion imaging (MAA, Microsphere) –pulmonary embolism.

Cardiac studies- static blood pool imaging, Rest/stress myocardial imaging, infarct imaging, MUGA, gated blood pool study, first pass study (shunt detection), placental imaging

Central nervous study- cerebral blood flow dynamic studies, static brain imaging, cisternography and ventriculoatrial and ventriculoperitoneal shunts. Use of  $^{201}\text{Tl}$ ,  $^{18}\text{F}$ FDG and  $\text{NH}_3$  for cardiac studies.

Endocrine studies- thyroid imaging and uptake ( $^{99m}\text{Tc}$  and  $^{131}\text{I}$ ), Perchlorate discharge test,  $\text{T}_3/\text{T}_4$  suppression test, TSH stimulation test.  $^{131}\text{I}$  whole-body imaging, parathyroid imaging, adrenal cortex imaging,  $^{131}\text{I}$ -MIBG imaging, testicular imaging.

### **Paper III :**

#### **Therapeutic Nuclear Medicine Procedures**

Choice of radionuclide-  $^{131}\text{I}$ ,  $^{32}\text{P}$ ,  $^{90}\text{Sr}$ ,  $^{153}\text{Sm}$ ,  $^{186}\text{Re}$ ,  $^{90}\text{Y}$  etc.

Choice of radiopharmaceuticals, therapy procedures, hyperthyroidism, thyroid carcinoma, neural crest tumours, painful bone metastasis, polycythemia Vera, rheumatoid arthritis, osteoarthritis.

Pre and post therapy imaging and patient preparation

### **Paper IV :**

#### **Quality Control (QC) of Nuclear Medicine equipment**

QC of Dose calibrator, gamma ray spectrometer, rectilinear scanner, planar gamma camera SPECT, coincidence Camera and PET. Phantoms for QC, software phantoms, Internet based QC.

Film processing and film characteristics – ASA, fog density, lattices, slope, etc.  
Dark room quality control.

### **Paper V :**

#### **Radiopharmacy - Part II**

QC of kits – radiochemical purity, sterility checks, chromatography, pyrogen test, bio- distribution studies,  $^{99}\text{Mo}$  break through test.

Quality control of PET radiopharmaceuticals by TLC scanner, HPLC and Gas Chromatography.

QC in hospital radiopharmacy practices - includes aseptic practices & pharmaceutical safety aspects. Good manufacturing practice (GMP), ISO and ISI standards in radiopharmaceuticals.

Mechanism of localisation of radiopharmaceutical in different organs, recent trends in radiopharmaceuticals, iodination and technique of iodination. Various receptor imaging, ligands and labelling of molecules. Regulations, ethics and registration of radiopharmaceuticals.

## **Paper VI :**

### **Health Physics and Radiation Protection**

Radiation Protection Instruments, Radiation dosimetry, Radiation protection in nuclear medicine, Radiation quantities and units, Radiation hazards– evaluation and control; basic principles and operational limits; , Basic safety standards, Planning of nuclear medicine laboratories; radiation monitoring, decontamination procedures; radiation protection in diagnostic and therapeutic nuclear medicine- protection of the patient. Guidance level for diagnostic administration, misadministration and preventive measures.

Protection of staff, public and environment, radiation surveillance procedures. Radioactive waste management:, Transport of radioactive material:

Radiation emergencies, preparedness and record keeping:

Large-scale spillage, leakage of radioactivity substance in environment, accidental inhalation, death of a patient with radioactivity , Regulatory aspects & licensing

The Atomic Energy Act, Surveillance procedures issued under the Rules, Notifications issued under RPR, 1971, AERB Safety Directive, Safety code for NM facility, Duties of Medical physicist/ technologists/ radiopharmacists,

RSO, Regulatory clearance-Approval of NM Lab, Ethics, registration of radiopharmaceuticals and their use

### **Patient Care and Hospital practice**

Behavioural science (Care of the patient): Management of ambulatory and non-ambulatory patients and aids for this, elementary hygiene and cleanliness, nursing care, first aid, principles of asepsis- handling of contaminated swabs, used syringes and needles, handling of secretions, sterilization methods, preparation of patients for general nuclear medicine procedures, precautions- administration of radiopharmaceutical to children, nursing and care taking mothers and pregnant women.

### **Practical / demonstrations**

1. Isoresponse curve of different collimators.
2. Line spread function of collimators
3. Phantom studies for scintigraphy
4. In-vitro radiospirometry.
5. Radiation survey of nuclear medicine lab
6. Contamination levels and methods of decontamination
7. Radiopharmacy procedure, elution of generators, preparation of different radiopharmaceuticals.
8. Grey scale calibration (calibration of a photo scanner).
9. Organ Imaging
10. Profile scanning (whole body counter)

11. Analog studies with single or multiple probes.
12. Dilution principle (blood volume).
13. In-vitro sample measurement of various types.
14. Flow measurements
15. Renogram
16. Thyroid uptake unit and collimator response
17. Radioimmunoassays of various types
18. Formulation  $^{99m}\text{Tc}$  compounds from kits
19. Determination of  $^{99}\text{Mo}$  breakthrough in  $^{99m}\text{Tc}$
20. Q.C of Dose Calibrator
21. Q.C of Gamma Camera
22. Q.C of SPECT
23. QC of radiopharmaceuticals by paper chromatography.
24. QC of PET radiopharmaceuticals by TLC scanner, HPLC & Gas chromatography
25. Rapid determination of radiochemical purity of radiopharmaceuticals.
26. Animal biodistribution –unknown radiopharmaceutical.
27. Pre and post  $^{131}\text{I}$ -therapy imaging and patient preparation

- \* **Practical (One day) – Whole Body PET Scan & Question related to all system.**
- \* **Two weeks in house participation Training in Medical Cyclotron.**
- \* **Inclusion of MRI posting for to 4 weeks.**

### **Project :**

At the beginning of the 2<sup>nd</sup> year, the candidates will be allotted a Project by the Guide, which has to be submitted to the University by the candidate two months before the Final Examination for approval.

Log book has to be maintained by each candidate, which includes, investigations performed, Journal club, Seminars conducted, conferences if attended, etc.

### **Suggested Books and Journals:**

| Name of Book                                             | Editor's Name               |
|----------------------------------------------------------|-----------------------------|
| First Year MSc (NMT)                                     | -                           |
| <b>Paper II : Anatomy, Physiology &amp; Biochemistry</b> |                             |
| <b>Text Books</b>                                        |                             |
| 1 Human Anatomy                                          | B D Chaurasia               |
| 2 Essentials of Medical Physiology                       | A B Singha Mahapatra et al  |
| 3 A Text Book of Biochemistry                            | S.S Randhawn /Sarath C Bose |
| <b>Reference Books</b>                                   |                             |
| 1 Anatomy & Physiology                                   | Ross & Wilson               |
| 2 Concise textbook of Biochemistry                       | Pattabiraman                |
| 3 Human Physiology, Biochemistry & Basic Medicine        | Lawrence A Cole et al       |

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| <b>Paper III : Computers, Fundamentals of Electricity &amp; Electronics</b> | -                         |
| <b>Text Books</b>                                                           |                           |
| 1 Computers in Nuclear Medicine Part I<br>Distance Education Series         | IAEA                      |
| 1 Computers in Nuclear Medicine Part II<br>Distance Education Series        | IAEA                      |
| 3 All New Electronics – Self Teaching guide                                 | Henry Kybett, Earl Baysen |
| <b>Reference Books</b>                                                      |                           |
| 1 Fundamentals and Electronics for Engineering                              | --                        |
| 2 Physics in Nuclear Medicine                                               | Sorenson                  |
| 3 Getting started in Electronics                                            | Forest M MIMS II          |

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|-------------------------------------------------------------|-------------------|
| <b>Paper IV : Mathematics &amp; Statistics</b>              | -                 |
| <b>Text Books</b>                                           |                   |
| 1 Statistical & Mathematical techniques in Nuclear Medicine | G S Pant          |
| 2 Elements of Statistical Learning                          | Jerome H Friedman |
| 3 Principles of Statistics                                  | M G Bulmer        |
| <b>Reference Books</b>                                      |                   |
| 1. Research Methodology – Methods and Techniques            | C R Kothari       |
| 2 Physics in Nuclear Medicine                               | Sorenson          |
| 3 Text book of Nuclear Medicine Technology & Techniques     | Bernier           |

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|------------------------------------------------------------|-------------------------------------------|
| <b>Paper V Radiation Physics &amp; Radiation Chemistry</b> |                                           |
| <b>Text Books</b>                                          |                                           |
| 1 Physics in Nuclear Medicine                              | Sorenson                                  |
| 2 Nuclear Medicine Physics (A HandBook )                   | D L Bailey et al                          |
| 3 Fundamentals of Radiation Chemistry                      | A Mazumder                                |
| <b>Reference Books</b>                                     |                                           |
| 1 Essentials of Nuclear Medicine Physics & Instrumentation | Pawnsor                                   |
| 2 Nuclear Medicine & PET CT Technology & Techniques        | Paul E Christian Kristen M Waterstramrich |
| 3 Radioactivity 2 <sup>nd</sup> Edition                    | Michael L Annuziata                       |

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| <b>Paper VI Radiation Biology</b>                          |                                 |
| <b>Text Books</b>                                          |                                 |
| 1 Radiation Biology : A Handbook for Students              | IAEA                            |
| 2 Essentials of Radiation Biology & Protection             | -                               |
| 3 Radiation Biology                                        | G B Saha                        |
| <b>Reference Books</b>                                     |                                 |
| 1 Radiation Biology of Medical Imaging                     | Charles A Kelsey                |
| 2 Biophysics                                               | –                               |
| 3 Biological Effects of Dosimetry on Ionizing Radiation    | –                               |
|                                                            |                                 |
| <b>Paper VII Nuclear Medicine Instrumentation-I</b>        |                                 |
| <b>Text Books</b>                                          |                                 |
| 1 Essentials of Nuclear Medicine Physics : A Handbook      | D L Bailey et al                |
| 2 Physics in Nuclear Medicine                              | Sorenson                        |
| 3 Essentials of Nuclear Medicine Physics & Instrumentation | Pawsner                         |
| <b>Reference Books</b>                                     |                                 |
| 1 Molecular Imaging – Principles & Practice                |                                 |
| 2 Nuclear Medicine Physics – A Handbook                    | D L Bailey et al                |
| 3 Nuclear Medicine & PET CT Technology & Techniques        | Paul E Kristen M Waterstramrich |
|                                                            |                                 |
| <b>Paper VIII Radiopharmacy -I</b>                         |                                 |
| <b>Text Books</b>                                          |                                 |
| 1 Fundamentals of Nuclear Pharmacy                         | Gopal B Saha                    |
| 2 Nuclear Medicine & PET CT Technology & Techniques        | Paul E Kristen M Waterstramrich |
| 3 Technetium 99m Radiopharmaceuticals                      | IAEA                            |
| <b>Reference Books</b>                                     |                                 |
| 1 The Mayo Clinic Manual of Nuclear Medicine               | Michael K O Connor              |
| 2 Molecular Imaging – Principles and Practice              | Ralph Weishlader Brian Ross     |
| 3 The Requisites – Nuclear Medicine Ch 1-10                | Harvey A Zeissmann et al        |

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| <b>Paper IX Clinical Nuclear Medicine Techniques -1</b>              |                                     |
| <b>Text Books</b>                                                    |                                     |
| 1. Nuclear Medicine in Clinical Diagnosis & Treatment (Part 1) Vol 1 | I D C Murray, P J Ell               |
| 2. Nuclear Medicine in Clinical Diagnosis & Treatment (Part 2) Vol 2 | I D C Murray, P J Ell               |
| 3. Nuclear Medicine in Clinical Diagnosis & Treatment (Part 3) Vol 2 | I D C Murray, P J Ell               |
| <b>Reference Books</b>                                               |                                     |
| 1. Atlas of PET CT : A quick guide to Image Interpretation           | Stefano Fanti                       |
| 2 Nuclear Cardiac Imaging : Principles and Applications              | Ami E Iskandrian , P J Ell          |
| 3 Thyroid : A fundamental and Clinical Text Vol 1<br>Section 1-3     | Lewis E Braverman David<br>S Cooper |

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| <b>Second Year M.Sc (NMT)</b>                              |                                              |
| <b>Paper I Nuclear Medicine Instrumentation -II</b>        |                                              |
| <b>Text Books</b>                                          |                                              |
| 1 Physics in Nuclear Medicine Sorenson                     |                                              |
| 2 Nuclear Medicine & PET CT Technology & Techniques        | Paul E Christian Kristen<br>M Waterstramrich |
| 3 Essentials of Nuclear Medicine Physics & Instrumentation | Pawsner                                      |
| <b>Reference Books</b>                                     |                                              |
| 1 Quality control of Nuclear Medicine Instruments          | IAEA                                         |
| 2 Quality Control of Nuclear Medicine Instrumentation      | G S Pant                                     |
| 3 Nuclear Medicine Physics (A HandBook )                   | D L Bailey et al                             |

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|-----------------------------------------------------------------|----------------------------------------------|
| <b>Paper II Clinical Nuclear Medicine Techniques II</b>         |                                              |
| <b>Text Books</b>                                               |                                              |
| 1 Essentials of Nuclear Medicine Imaging                        | Fried A Mettler J R<br>Miltopn J Guilberteau |
| 2 Clinical Nuclear Medicine                                     | Gary J R Cook, Michael N Maisey              |
| 3 Diagnostic Nuclear Medicine                                   | Christian Schiepers                          |
| <b>Reference Books</b>                                          |                                              |
| 1 Atlas of PET CT : A Quick guide to Image Interpretation       | Stefano Fanti                                |
| 2 A Personal History of Nuclear Medicine                        | Henry N Wagner                               |
| 3 Nuclear Medicine Clinical Diagnosis & Treatment               | IDC Murray P J Ell                           |
|                                                                 |                                              |
| <b>Paper III : Therapeutic Nuclear Medicine Procedures</b>      |                                              |
| <b>Text Books</b>                                               |                                              |
| 1 Nuclear Medicine Therapy                                      | Janet F Eary /Winfried Brenner               |
| 2 Targeted Radionuclide therapy                                 | Tod W Speer                                  |
| 3 Nuclear Medicine Clinical Diagnosis & Treatment               | IDC Murray P J Ell                           |
| <b>Reference Books</b>                                          |                                              |
| 1 Thyroid : A Fundamental & Ckinical Text Vol 1<br>Section 1- 3 | Lewis E Braverman David<br>S Cooper          |
| 2 Thyroid : A Fundamental & Ckinical Text Vol 1<br>Section 4-8  | Lewis E Braverman David<br>S Cooper          |
| 3 The Mayo Clinic Manual of Nuclear Medicine                    | Michael K O'Connor                           |
|                                                                 |                                              |
| <b>Paper IV : Quality Control of Nuclear Medicine Equipment</b> |                                              |
| <b>Text Books</b>                                               |                                              |
| 1 Quality control of Nuclear Medicine<br>Instruments TECDOC     | IAEA, TECDOC 601                             |
| 2 Quality Control in Nuclear Medicine<br>Instrumentation        | G S Pant                                     |
| 3 Nuclear Medicine & PET CT Technology & Techniques             | Paul E Christian Kristen<br>M Waterstramrich |

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|-----------------------------------------------------------|----------------------------------------------|
| <b>Reference Books</b>                                    |                                              |
| 1 Quality Assurance of SPECT System                       | IAEA                                         |
| 2 Quality Assurance of PET & PET CT                       | IAEA                                         |
| 3 PET CT Atlas on QC and Image artifacts                  | IAEA                                         |
|                                                           |                                              |
| <b>Paper V : Radiopharmacy -II</b>                        |                                              |
| <b>Text Books</b>                                         |                                              |
| 1 Fundamentals of Nuclear Pharmacy                        | Gopal B Saha                                 |
| 2 Nuclear Medicine & PET CT Technology & Techniques       | Paul E Christian Kristen<br>M Waterstramrich |
| 3 Radiopharmaceuticals                                    | M H Patel                                    |
| <b>Reference Books</b>                                    |                                              |
| 1 Essentials of Nuclear Medicine Imaging                  | Fried A Mettler                              |
| 2 Molecular Imaging – Principles & Practice               | Ralph Weishlader Brian Ross                  |
| 3 Basics of PET Imaging                                   | Gopal B Saha                                 |
|                                                           |                                              |
| <b>Paper VI Health Physics &amp; Radiation Protection</b> |                                              |
| <b>Text Books</b>                                         |                                              |
| 1 Fundamentals of Nuclear Medicine Dosimetry              | Michael G Stabin                             |
| 2 Radiation Safety Officer Workshop Book                  | AERB                                         |
| 3 AERB Safety Guidelines & Codes for Nuclear Medicine     | AERB                                         |
| <b>Reference Books</b>                                    |                                              |
| 1 Basics of PET Imaging                                   | Gopal B Saha                                 |
| 2 Physics of Nuclear Medicine                             | Sorenson                                     |
| 3 AERB Safety Guidelines                                  | AERB                                         |

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