MAHATMA GANDHI UNIVERSITY
of
MEDICAL SCIENCES & TECHNOLOGY
JAIPUR

Syllabus

MD - NUCLEAR MEDICINE

(3 Years Post Graduate Degree Course)

Edition 2021-22

Notice

1. Amendment made by the National Medical Commission (NMC) in Rules/Regulations of Post Graduate Medical Courses shall automatically apply to the Rules/Regulations of the Mahatma Gandhi University of Medical Sciences & Technology (MGUMST), Jaipur.

2. The University reserves the right to make changes in the syllabus/books/guidelines, fees-structure or any other information at any time without prior notice. The decision of the University shall be binding on all.

3. Jurisdiction of all the court cases shall be Jaipur Bench of Hon'ble Rajasthan High Court only.

RULES & REGULATIONS

MD IN NUCLEAR MEDICINE (MD20)

(3 Years Post Graduate degree course)

TITLE OF THE COURSE:
It shall be called Doctor of Medicine.

ELIGIBILITY FOR ADMISSION:
No candidate of any category (including NRI quota) shall be eligible for admission to MD/MS courses, if he or she has not qualified NEET PG (MD/MS) conducted by National Board of Examinations or any other Authority appointed by the Government of India for the purpose.

(1) **General Seats**

(a) Every student, selected for admission to postgraduate medical course shall possess recognized MBBS degree or equivalent qualification and should have obtained permanent Registration with the Medical Council of India, or any of the State Medical Councils or should obtain the same within one month from the date of his/her admission, failing which the admission of the candidate shall be cancelled;

(b) Completed satisfactorily one year's rotatory internship or would be completing the same before the date announced by the University for that specific year as per MCI rules after passing 3rd professional MBBS Part II Examination satisfactorily.

(c) In the case of a foreign national, the Medical Council of India may, on payment of the prescribed fee for registration, grant temporary registration for the duration of the postgraduate training restricted to the medical college/institution to which he/she is admitted for the time being exclusively for postgraduate studies; however temporary registration to such foreign national shall be subject to the condition that such person is duly registered as medical practitioner in his/her own country from which he has obtained his basic medical qualification and that his degree is recognized by the corresponding Medical Council or concerned authority.

(2) **NRI Seats**

(a) Students from other countries should possess passport, visa and exchange permits valid for the period of their course of study in this Institution and should also observe the regulations of both central and state governments regarding residential permits and obtain no-objection certificate from the same.

(b) The candidate should have a provisional "Student Visa". If he comes on any other visa and is selected for admission, he will have to first obtain a student visa from his country and then only he will be allowed to join the course. Therefore it is imperative to obtain provisional student visa before coming for Counseling.

(c) This clause is applicable to NRI/Foreign Students only.

CRITERIA FOR SELECTION FOR ADMISSION:

(1) **NRI Quota**

15% of the total seats are earmarked for Foreign National / PIO / OCI/ NRI / Ward of NRI/NRI sponsored candidates who would be admitted on the basis of merit obtained in NEET PG or any other criteria laid down by Central Government/MCI.

(2) **Remaining Seats (Other than NRI Quota Seats)**

(a) Admissions to the remaining 85% of the seats shall be made on the basis of the merit obtained at the NEET conducted by the National Board of Examinations or any other Authority appointed by the Government of India for the purpose.
(b) The admission policy may be changed according to the law prevailing at the time of admission.

COUNSELING/INTERVIEW:

(1) Candidates in order of merit will be called for Counseling/Interview and for verification of original documents and identity by personal appearance.
(2) Counseling will be performed and the placement will be done on merit-cum-choice basis by the Admission Board appointed by the Government of Rajasthan.

RESERVATION:

Reservation shall be applicable as per policy of the State Government in terms of scheduled caste, scheduled tribe, back ward class, special back ward class, women and handicapped persons.

ELIGIBILITY AND ENROLMENT:

Every candidate who is admitted to MD/MS course in Mahatma Gandhi Medical College & Hospital shall be required to get himself/herself enrolled and registered with the Mahatma Gandhi University of Medical Sciences & Technology after paying the prescribed eligibility and enrolment fees.

The candidate shall have to submit an application to the MGUMST for the enrolment/eligibility along with the following original documents with the prescribed fees (upto November 30 of the year of admission without late fees and upto December 31 of the year of admission with late fees) –

(a) MBBS pass Marks sheet/Degree certificate issued by the University (Ist MBBS to Final MBBS)
(b) Certificate regarding the recognition of medical college by the Medical Council of India.
(c) Completion of the Rotatory Internship certificate from a recognized college.
(d) Migration certificate issued by the concerned University.
(e) Date of Birth Certificate
(f) Certificate regarding registration with Rajasthan Medical Council / Medical Council of India / Other State Medical Council.

REGISTRATION

Every candidate who is admitted to MD/MS course in Mahatma Gandhi Medical College & Hospital shall be required to get himself/herself registered with the Mahatma Gandhi University of Medical Sciences & Technology after paying the prescribed registration fees.

The candidate shall have to submit an application to the MGUMST for registration with the prescribed fees (upto November 30 of the year of admission without late fees upto December 31 of the year of admission with late fees).

DURATION OF COURSE:

The course shall be of 3 years duration from the date of commencement of academic session.

PERIOD OF TRAINING:

(1) The period of training for obtaining Post graduate degrees (MD/MS) shall be three completed years including the period of examination.
(2) It shall however be two years for candidates who have obtained the recognised PG Diploma in the subject.

MIGRATION:

No application for migration to other Medical Colleges will be entertained from the students already admitted to the MD/MS course at this Institute.

METHODS OF TRAINING FOR MD/MS:

Method of training for MD/MS courses shall be as laid down by the Medical Council of India.

ONLINE COURSE IN RESEARCH METHODS

i. All postgraduate students shall complete an online course in Research Methods to be conducted by an Institute(s) that may be designated by the Medical Council of India by way of public notice, including on its website and by Circular to all Medical Colleges. The students shall have to register on the portal of the designated institution or any other institute as indicated in the public notice.
ii. The students have to complete the course by the end of their 2nd semester.
iii. The online certificate generated on successful completion of the course and examination thereafter, will be taken as proof of completion of this course
iv. The successful completion of the online research methods course with proof of its completion shall be essential before the candidate is allowed to appear for the final examination of the respective postgraduate course.

This requirement will be applicable for all postgraduate students admitted from the academic year 2019-20 onwards

ATTENDANCE, PROGRESS AND CONDUCT:

(1) **Attendance:**

(a) 80% attendance in each course is compulsory. Any one failing to achieve this, shall not be allowed to appear in the University examination.

(b) A candidate pursuing MD/MS course shall reside in the campus and work in the respective department of the institution for the full period as a full time student. No candidate is permitted to run a clinic/work in clinic/laboratory/ nursing home while studying postgraduate course. No candidate shall join any other course of study or appear for any other examination conducted by this university or any other university in India or abroad during the period of registration. Each year shall be taken as a unit for the purpose of calculating attendance.

(c) Every candidate shall attend symposia, seminars, conferences, journal review meetings, grand rounds, CPC, CCR, case presentation, clinics and lectures during each year as prescribed by the department and not absent himself / herself from work without valid reasons. Candidates should not be absent continuously as the course is a full time one.

(2) **Monitoring Progress of Studies- Work diary/Log Book:**

(a) Every candidate shall maintain a work diary in which his/her participation in the entire

training program conducted by the department such as reviews, seminars, etc. has to be chronologically entered.

(b) The work scrutinized and certified by the Head of the Department and Head of the Institution is to be presented in the University practical/clinical examination.

(3) **Periodic tests:**

There shall be periodic tests as prescribed by the Medical Council of India and/ or the Board of Management of the University, tests shall include written papers, practical/clinical and viva voce.

(4) **Records:**

Records and marks obtained in tests will be maintained by the Head of the Department and will be made available to the University when called for.

THESIS:

(1) Every candidate pursuing MD/MS degree course is required to carry out work on research project under the guidance of a recognized post graduate teacher. Then such a work shall be submitted in the form of a Thesis.

(2) The Thesis is aimed to train a postgraduate student in research methods & techniques.

(3) It includes identification of a problem, formulation of a hypothesis, designing of a study, getting acquainted with recent advances, review of literature, collection of data, critical analysis, comparison of results and drawing conclusions.

(4) Every candidate shall submit to the Registrar of the University in the prescribed format a Plan of Thesis containing particulars of proposed Thesis work within six months of the date of commencement of the course on or before the dates notified by the University.

(5) The Plan of Thesis shall be sent through proper channel.

(6) Thesis topic and plan shall be approved by the Institutional Ethics Committee before sending the same to the University for registration.

(7) Synopsis will be reviewed and the Thesis topic will be registered by the University.

(8) No change in the thesis topic or guide shall be made without prior notice and permission from the University.

(9) The Guide, Head of the Department and head of the institution shall certify the thesis. Three printed copies and one soft copy of the thesis thus prepared shall be submitted by the candidate to the Principal. While retaining the soft copy in his office, the Principal shall send the three printed copies of the thesis to the Registrar six months before MD/MS University Examinations. Examiners appointed by the University shall evaluate the thesis. Approval of Thesis at least by two examiners is an essential pre-condition for a candidate to appear in the University Examination.

(10) Guide: The academic qualification and teaching experience required for recognition by this University as a guide for thesis work is as laid down by Medical Council of India/Mahatma Gandhi University of Medical Sciences & Technology, Jaipur.

(11) Co-guide: A co-guide may be included provided the work requires substantial contribution from a sister department or from another institution recognized for teaching/training by Mahatma Gandhi University of Medical Sciences & Technology, Jaipur/Medical Council of India. The co-guide shall be a recognized postgraduate teacher.

(12) Change of guide: In the event of a registered guide leaving the college for any reason or in the event of death of guide, guide may be changed with prior permission from the

University.

ELIGIBILITY TO APPEAR FOR UNIVERSITY EXAMINATION:

The following requirements shall be fulfilled by every candidate to become eligible to appear for the final examination:

(1) Attendance: Every candidate shall have fulfilled the requirement of 80% attendance prescribed by the University during each academic year of the postgraduate course. (as per MCI rules)

(2) Progress and Conduct: Every candidate shall have participated in seminars, journal review meetings, symposia, conferences, case presentations, clinics and didactic lectures during each year as designed by the department.

(3) Work diary and Logbook: Every candidate shall maintain a work diary for recording his/her participation in the training program conducted in the department. The work diary and logbook shall be verified and certified by the Department Head and Head of the Institution.

(4) Every student would be required to present one poster presentation, to read one paper at a National/State Conference and to have one research paper which should be published/accepted for publication/ sent for publication to an indexed journal during the period of his/her post graduate studies so as to make him/her eligible to appear at the Post Graduate Degree Examination.

(5) Every student would be required to appear in and qualify the Pre-University Post graduate degree Mock examination. Post graduate students who fail to appear in or do not qualify the Pre-University Post graduate degree Mock examination shall not be permitted to appear in the final examination of the University.

The certification of satisfactory progress by the Head of the Department/ Institution shall be based on (1), (2), (3), (4) and (5) criteria mentioned above.

ASSESSMENT:

(1) The progress of work of the candidates shall be assessed periodically by the respective guides and report submitted to the Head of the Institution through the Head of the Department at the end of every six months. The assessment report may also be conveyed in writing to the candidate who may also be advised of his/her shortcomings, if any.

(2) In case the report indicate that a candidate is incapable of continuing to do the work of the desired standard and complete it within the prescribed period, the Head of the Institution may recommend cancellation of his/her registration at any time to the University.

(3) Formative Assessment:

(a) General Principles

i. The assessment is valid, objective, constructive and reliable.

ii. It covers cognitive, psychomotor and affective domains.

iii. Formative, continuing and summative (final) assessment is also conducted.

iv. Thesis is also assessed separately.

(b) Internal Assessment

i. The internal assessment is continuous as well as periodical. The former is based on the feedback from the senior residents and the consultants concerned. Assessment is held periodically.

ii. Internal assessment will not count towards pass/fail at the end of the program, but

will provide feedback to the candidate.

iii. The performance of the Postgraduate student during the training period should be monitored throughout the course and duly recorded in the log books as evidence of the ability and daily work of the student.

iv. Marks should be allotted out of 100 as under

1) Personal Attributes - 20 marks
   a. Behavior and Emotional Stability: Dependable, disciplined, dedicated, stable in emergency situations, shows positive approach.
   b. Motivation and Initiative: Takes on responsibility, innovative, enterprising, does not shirk duties or leave any work pending.
   c. Honesty and Integrity: Truthful, admits mistakes, does not cook up information, has ethical conduct, exhibits good moral values, loyal to the institution.
2) Clinical Work - 20 marks
   a Availability: Punctual, available continuously on duty, responds promptly on calls and takes proper permission for leave.
   b Diligence: Dedicated, hardworking, does not shirk duties, leaves no work pending, does not sit idle, competent in clinical case work up and management.
   c Academic Ability: Intelligent, shows sound knowledge and skills, participates adequately in academic activities and performs well in oral presentation and departmental tests.
   d Clinical Performance: Proficient in clinical presentations and case discussion during rounds and OPD work up. Preparing Documents of the case history/examination and progress notes in the file (daily notes, round discussion, investigations and management) Skill of performing bed side procedures and handling emergencies.
3) Academic Activities - 20 marks

   Performance during presentation at Journal club/ Seminar/Case discussion/Stat meeting and other academic sessions. Proficiency in skills as mentioned in job responsibilities.
4) End of term theory examination - 20 marks

   End of term theory examination conducted at end of 1st, 2nd year and after 2 years 9 months.
5) End of term practical examination - 20 marks
   a. End of term practical/oral examinations after 2 years 9 months.
   b. Marks for personal attributes and clinical work should be given annually by all the consultants under whom the resident was posted during the year. Average of the three years should be put as the final marks out of 20.
   c. Marks for academic activity should be given by the all consultants who have attended the session presented by the resident.
   d. The Internal assessment should be presented to the Board of examiners for due consideration at the time of Final Examinations.
   e. Yearly (end of 1st, 2nd & 3rd year) theory and practical examination will be conducted by internal examiners and each candidate will enter details of theory paper, cases allotted (2 long & 2 short) and viva.

f. Log book to be brought at the time of final practical examination.

APPOINTMENT OF EXAMINERS:

Appointment of paper setters, thesis evaluators, answer books evaluators and practical & viva voce examiners shall be made as per regulations of the Medical Council of India.

SCHEME OF EXAMINATION:

Scheme of examination in respect of all the subjects of MD/MS shall be as under :

(1) The examination for MD/MS shall be held at the end of three Academic Years.

(2) Examinations shall be organized on the basis of marking system.

(3) The period of training for obtaining MD/MS degrees shall be three completed years including the period of examination.

(4) The University shall conduct not more than two examinations in a year for any subject with an interval of not less than 4 months and not more than 6 months between the two examinations.

(5) The examinations shall consist of:

(a) Thesis :

i. Thesis shall be submitted at least six months before the main Theory examinations.

ii. The thesis shall be examined by a minimum of three examiners – one Internal and two External examiners who shall not be the examiners for Theory and Clinical/Practical.

iii. In departments where besides the two earmarked practical/clinical examiners no one else is a qualified P.G. teacher, in that case the Thesis shall be sent to the third external examiner who shall actually be in place of the internal examiner.

iv. Only on the acceptance of the thesis by any two examiners, the candidate shall be eligible to appear for the final examination.

v. A candidate whose thesis has been once approved by the examiners will not be required to submit the Thesis afresh, even if he/she fails in theory and/or practical of the examination of the same branch.

vi. In case the Thesis submitted by a candidate is rejected, he/she should be required to submit a fresh Thesis.

(b) Theory papers:

i. There shall be four theory papers.

ii. Each theory paper examination shall be of three hours duration.

iii. Each theory paper shall carry maximum 100 marks.

iv. The question papers shall be set by the External Examiners.

v. There will be a set pattern of question papers.

Every question paper shall contain three questions. All the questions shall be compulsory, having no choice.

Question No. 1 shall be of long answer type carrying 20 marks.

Question No. 2 shall have two parts of 15 marks each. Each part will be required to be answered in detail.

Question No. 3 shall be of five short notes carrying 10 marks each.

vi. The answer books of theory paper examination shall be evaluated by two External

and two internal examiners. Out of the four paper setters, the two paper setters will be given answer books pertaining to their papers and the answer books of the remaining two papers will be evaluated by two Internal Examiners. It will be decided by the President as to which paper is to be assigned to which Internal Examiner for evaluation.

vii. A candidate will be required to pass theory and practical examinations separately in terms of the governing provisions pertaining to the scheme of examination in the post graduate regulations. The examinee should obtain minimum 40% marks in each theory paper and not less than 50% marks cumulatively in all the four papers for degree examination to be cleared as "passed" at the said Degree examination.

(c) Clinical/ Practical & Oral examinations:

i. Clinical/Practical and Oral Examination of 400 marks will be conducted by at least four examiners, out of which two (50%) shall be External Examiners.

ii. A candidate will be required to secure at least 50% (viz. 200/400) marks in the Practical including clinical and viva voce examinations.

(6) If a candidate fails in one or more theory paper(s) or practical, he/she shall have to reappear in the whole examination i.e. in all theory papers as well as practical.

GRACE MARKS

No grace marks will be provided in MD/MS examinations.

REVALUATION / SCRUTINY:

No Revaluation shall be permitted in the MD/MS examinations. However, the student can apply for scrutiny of the answer books as per University Rules.

GUIDELINES FOR COMPETENCY BASED POSTGRADUATE TRAINING PROGRAMME FOR MD IN NUCLEAR MEDICINE

Preamble:

The purpose of PG education is to create specialists who would provide high quality health care and advance the cause of science through research & training.

Nuclear medicine is a multi-disciplinary practice and the training of medical doctors is critical to the performance of a Nuclear Medicine department. Successful post graduate students are awarded a final certificate, degree or diploma that is recognized by the government, local health authority and hospital employer as an assurance of specialist competence in Nuclear Medicine. Post graduate training programme in Nuclear Medicine consists of an integrated training course of three years duration and would enable the post graduate student to practice nuclear medicine safely.

The purpose of this document is to provide teachers and learners illustrative guidelines to achieve defined outcomes through learning and assessment. This document was prepared by various subject-content specialists. The Reconciliation Board of the Academic Committee has attempted to render uniformity without compromise to purpose and content of the document. Compromise in purity of syntax has been made in order to preserve the purpose and content. This has necessitated retention of "domains of learning" under the heading "competencies".

SUBJECT SPECIFIC LEARNING OBJECTIVES

The **objective** of the programme is to enable the post graduate student s to perform Nuclear Medicine practice, teaching and research independently and fulfill the manpower needs of ever expanding new branch of diagnostic and therapeutic medicine.

Post Graduate Training will consist of Theoretical and Practical Training:

SUBJECT SPECIFIC COMPETENCIES

By the end of the course, the student should have acquired knowledge (cognitive domain), professionalism (affective domain) and skills (psychomotor domain) as given below:

A. Cognitive domain

1. Should have knowledge of basic principles of radiation physics and its subsequent applications.
2. Should have knowledge of radiation protection principles.
3. Safe handling of radionuclides and their disposal.
4. Should have knowledge of International Commission for Radiological Protection (ICRP) and National Regulatory guidelines pertaining to nuclear medicine practice.
5. Should have knowledge of diagnostic tests, interpretation of results and pitfalls.
6. Good clinical practice of therapeutic nuclear medicine and dosimetry.
7. Should be able to conduct clinical research and write a thesis/dissertation under supervision.
8. Should develop good working relationship with user specialties and handling inter-specialty referrals

B. Affective domain:

1. Should be able to function as a part of a team, develop an attitude of cooperation with colleagues, and interact with the patient and the clinician or other colleagues to provide the best possible diagnosis or opinion.
2. Always adopt ethical principles and maintain proper etiquette in dealings with patients, relatives and other health personnel and to respect the rights of the patient including the right to information and second opinion.
3. Develop communication skills to word reports and professional opinion as well as to interact with patients, relatives, peers and paramedical staff, and for effective teaching.

C. Psychomotor domain

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

A) Basic Sciences Experiment:

1. Practicals related to Physics, Instrumentation and its quality Control.
2. Preparation of radiopharmaceuticals and their quality control.
3. Detection of contamination in various workplaces.
4. Characterization of unknown isotopes.
5. Management of accidental spillage.

B) Clinical Experiment:

1. GFR Estimation.
2. Esophageal transit time.
3. Gastric emptying time.
4. Renal transplant evaluation.
5. Determination of Ejection Fraction and RWMA (wall motion).

Syllabus

Course Content :

The syllabus is divided into the following four parts:

1. Basic Science aspects of Radiation Physics and its application to diagnostic/ therapeutic Nuclear Medicine
2. Diagnostic Nuclear Medicine and its applications
3. Therapeutic Nuclear Medicine and its applications
4. Recent Advances in Nuclear Medicine

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

Part I: Basic Science related to Nuclear Medicine

1.1 Radiation Physics and Instrumentation

a. Structure of atom, Natural and artificial radioactivity.

b. Modes of Radioactive decay.

c. Interaction of radiation with matter.

d. Principles of radiation detection and detectors.

e. Basic principles of production of radionuclides by reactors and cyclotrons.

f. Nuclear Medicine Instrumentation including Gamma Cameras, Single Photon Computed Tomography (SPECT), Positron Emission Tomography (PET), Hybrid Imaging Systems like SPECT/CT, PET/CT and PET/MR

g. Counting Systems: Well counters, liquid scintillation counters, spectrometers, Radioactive Iodine Uptake (RAIU) probe and radiation monitoring devices.

h. Quality control of Nuclear Instruments, as in (f and g).

i. Collimation of radiation detectors and the characteristics of various collimators, their response to point, line and plane sources.

j. Electronic instruments, such as pulse amplifiers, pulse height analyzer, count rate meters and computer interfaces including gating devices.

k. Software and hardware fusion technology, Digital Imaging and Communications in Medicine (DICOM) technology and Picture Archiving and Communication System (PACS).

1.2 Mathematics, Statistics and Computer Sciences.

a. Basic Mathematical concepts, counting statistics, probability distribution, Baysian and McNemmar statistics, parametric and non- parametric statistics.

b. Compartmental analysis and mathematical models of physiologic systems.

c. Basic aspects of computer structure, function and programming.

d. Computer applications with emphasis on digital image acquisition, analysis, processing and enhancement, tomographic reconstruction, display and

recordings of findings.

e. Fundamental of filters, their applications and uses.

1.3 Radiation Biology

a. The biological effects of radiation exposure with emphasis on the effects of low level exposure.

b. Methods of reducing unnecessary radiation exposure to patients, personnel and environment.

c. ICRP recommendations and their amendments from time to time and other international recommendations, environmental regulations- regarding limits of radiation exposure, handling of radioactive patients, transport of radioactivity material and disposal of radioactive wastes.

d. The diagnosis, evaluation and treatment of radiation over exposure in any form.

Part 2: Diagnostic Nuclear Medicine

2.1 Radiopharmaceuticals

The chemical, physical and biological properties of radiopharmaceuticals used in Nuclear Medicine investigations; production, Quality Control and Regulations of hospital based-Nuclear Pharmacy.

The emphasis will be on:

a. Physical and chemical characteristics of radionuclide used in diagnostic Nuclear Medicine

b. Criteria for selection of radionuclide for diagnostic purposes

c. Biological behavior of radiopharmaceuticals

d. Quality control

e. Mechanism of localization

f. Positron Emitting radionuclides, target reactions and their radiopharmaceuticals chemistry, various synthetic modules.

g. Specific topics on Radiopharmaceuticals: Bone seeking, hepatobiliary, brain and cerebrospinal fluid (CSF), renal, thyroid, parathyroid, infection imaging, Tumor Seeking, cardiac imaging etc.

h. Good Manufacturing Practice (GMP) and Laws pertaining to in-house manufacturing of Radiopharmaceuticals.

i. Radiopharmaceuticals for Research.

2.2 *In vivo* Diagnostic Imaging

a. General clinical indications for organ imaging; normal and altered anatomy, physiology, biochemistry and metabolism of various organs. Must learn the technical aspects of performing the procedures including proper patient preparation and patient management before, during and after the procedure.

b. *In vivo* imaging and/or functional studies including brain Single Photon Emission Computed Tomography (SPECT), tracing of cerebrospinal fluid pathways, thyroid imaging, salivary glands, lungs, heart, gastrointestinal, hepatobiliary system, spleen, kidney, prostate, adrenal, bone and joints, bone marrow evaluation etc.

c. The use of physiologic gating techniques for functional studies and patient monitoring during intervention, both physical exercise and using pharmacological stress agents

d. Cellular kinetics, absorption and excretion analysis, nuclear hematology and metabolic balance studies using radiotracers.

e. Comparative analysis of Nuclear Medicine procedures with X-ray, Ultrasound, Echo, MRI, CT and angiography etc.

f. Nuclear Cardiology: Stress and redistribution studies using Thallium^{201} and other technetium-based myocardial perfusion agents; myocardial viability, Gated SPECT studies, etc.

g. Positron Emission Tomography (PET): All indications for use of PET imaging in oncology, cardiology, neurosciences and psychiatric disorders.

2.3 *In vitro* Studies

a. Principles of Radioimmunoassay (RIA), quality control and data analysis for various hormones and drugs assays.

b. Glomerular Filtration Rate (GFR) estimation, Red Cell Survival, Red Cell Mass using chromium and C^{14} urea Breath test.

Part 3: Therapeutic Nuclear Medicine

3.1 Principles of Internal Dosimetry: Calculation of the radiation dose from internally administered radionuclide

3.2 Characteristics of Radionuclides/Radiopharmaceuticals for radionuclide therapy

3.3 Radiation protection in therapeutic set up: Design of Isolation ward as per the norms of Atomic Energy Regulatory Board (AERB)

3.4 Principles of OPD and in-door therapy administration

3.5 Therapy in thyroid disorders; benign thyroid diseases, aetiology of hyperthyroidism, various modalities of treatment and follow up strategy, long-term outcome and various national and international regulations pertaining to therapeutic administration of radionuclides.

Therapy in thyroid disorders; aetiopathology, classification and diagnosis of thyroid nodules and malignancies- various modalities of treatment and follow-up strategies, long-term outcome and various national and international regulations pertaining to therapeutic administration of radionuclides.

3.6 Bone pain palliation using various radionuclides such as P^{32}, Sr^{89}, Y^{90}, Sm^{153}, Ra^{223}, Lu^{177} etc.

3.7 Radiosynevectomy

3.8 Radiopeptide therapy and Radioconjugate therapy

3.9 Radioimmunotherapy

3.10 Locoregional internal radiation therapy

3.11 Research agents in radionuclide therapy

Part 4: Recent Advances in Nuclear Medicine

Covering all aspects of the following areas:

4.1 Instrumentation

4.2 Radiopharmaceuticals

4.3 Diagnostic procedures

4.4 Therapeutic procedures

TEACHING AND LEARNING METHODS

Teaching methodology should consist of:

1. Didactic lectures in Physics related to Nuclear Medicine, radiopharmacy, radioisotopes techniques, instrumentation, data processing and quality control.
2. Participation in the daily routine work of the department including work rounds of patients admitted for radionuclide therapy. The postgraduate students shall be required to participate in the teaching and training programme of undergraduate students and interns.
3. Presentation of cases in the reporting sessions of the department.
4. **Log book:** Log book will be maintained meticulously to record all training done and Log books shall be checked and assessed periodically by the faculty members imparting the training.
5. A postgraduate student of a postgraduate degree course in broad specialities/super specialities would be required to present one poster presentation, to read one paper at a national/state conference and to present one research paper which should be published/accepted for publication/sent for publication during the period of his postgraduate studies so as to make him eligible to appear at the postgraduate degree examination.
6. Active participation in the combined clinical meetings with other departments for case discussions.
7. Regular participation in department journal clubs, Seminars and other periodical CME programmes.
8. Participation in the Seminars and CME programme of allied departments.
9. Department should encourage e-learning activities.
10. **Rotation:**

Apprenticeship/Rotation in:

a) Radio-diagnosis 03 months [CT 2 mo and MR 1 mo]

b) Cardiac stress lab 02 months

c) Immunoassay lab 01 month

During the training programme, patient safety is of paramount importance; therefore, skills are to be learnt initially on the models, later to be performed under supervision followed by performing independently; for this purpose, provision of skills laboratories in medical colleges is mandatory.

The year-wise schedule of training would be as follows:

Year 1

(a) Scientific principles:

- Basic physics and mathematics,
- Instrumentation,
- Principles of computing,
- Basic radiation biology and radiation protection,
- Basic radiopharmacy and radiochemistry,
- Principles of tracer technology.

(b) Clinical Nuclear Medicine:

- **Diagnostic**: Normal and abnormal appearances of images, mode of pharmaceutical uptake; normal variants and common artifacts in bone, heart, lung, kidney, brain, thyroid, tumour and infection images.
- **Therapeutic**: Basic principles of radionuclide therapy; treatment of hyperthyroidism, thyroid cancer and metastatic bone pain.
- **Principles of radiation protection**: ALARA (as low as reasonably achievable) ALARP (as low as reasonably practicable).

Year 2

(a) Requirements of Year 1 in greater depth:

- Tracer kinetics;
- Computing and image processing;
- Radiobiology including the biological effects of high and low level radiation;
- Linear hypothesis and the threshold hypothesis of the biological response to low level radiation;
- The effective dose equivalent and the calculation of radiation dose from radiopharmaceuticals.

(b) Radiopharmacy:

- Properties of commonly used diagnostic and therapeutic radiopharmaceuticals;
- Production of radionuclides by reactors, cyclotrons and radionuclide generators;
- Quality assurance and quality control of radiopharmaceuticals.

Year 3

(a) Requirements of Year 2 in greater depth:

- Principles of radiology including ultrasound, computerized tomography and magnetic resonance imaging.
- Co-registration of nuclear medicine images and those from other imaging techniques.
- Diagnostic: special investigations in cardiology, lung disease, gastroenterology, hepato-biliary diseases, nephro-urology, neurology and psychiatry, endocrinology, haematology, oncology and infection.

(b) Therapeutic applications:

- Treatment of bone metastases, neural crest tumors, prostate malignancies, solid malignancies;
- Use of radionuclide monoclonal antibodies and radionuclide labeled peptides for tumor therapy.

(c) Further practice and experience of work accomplished in years 1 to 3:

- Legal and regulatory requirements,
- Audit,
- Departmental management,
- Research techniques and evaluation,
- Teaching and training.

Practical training

The post graduate students are obliged to play an active 'in-service' role in the practice of Nuclear Medicine to familiarize themselves with all the techniques required as a nuclear medicine practitioner, such as:

- Protocols of *in vivo* and therapeutic procedures;
- Data acquisition and processing with various equipments, quality control of instruments and labeled agents;
- Interventional procedures, including physiological, pharmacological, and mental stress for diagnostic application, and all therapeutic interventions;
- *In vitro* protocols and procedures, if appropriate.

Since post graduate students will take on the responsibilities of a nuclear physician, they must pass a qualifying test that covers both theoretical knowledge and practical abilities in the daily practice of nuclear medicine.

SUGGESTED SCHEDULE FOR POST-GRADUATE TRAINING

Subject	Duration (hrs)	Suggested content of teaching	Recommended practice and time period
Nuclear physics	40	Decay features, spectrum, Radioisotope production & detection	Reactor-cyclotron generator, Radioisotope identification (5-7 days)
Radiochemistry	40	Labelling, technical design & quality control, interaction, kinetics	Synthesis, labelling, quality control, animal test (3-4 wks)
Radiobiology	40	Dosimetry, bio-modelling, tracer technology, radiation protection	Dosage-effect, molecular biology, radiation injury (4 wks)
Instrumentation	100	Scintillating camera, SPECT, imaging procedure, computer	Daily operation and quality control, trouble shooting (4 wks)
Related fields	50	Medical imaging modalities, epidemiology, statistics	Short round (6 wks)
Clinical use	240-300	Cardiology, neurology, GI tract, respiratory, endocrine, bones, haematology, tumour and infection	Clinical practice, image interpretation etc. (12-18 months)
In-vitro use	10	RAIU, RBC mass, survival, hypersplenism GFR measurements	RAIU practice (2 wks) GFR estimation (4 weeks)
Therapy	60	RIT, Palliation	Ward duty (3-4 months)

Posting in CT scan and MRI rooms is recommended as an aid to PET Scan imaging.

ASSESSMENT

FORMATIVE ASSESSMENT, during the training programme

Formative assessment should be continual and should assess medical knowledge, patient care, procedural & academic skills, interpersonal skills, professionalism, self directed learning and ability to practice in the system.

General Principles

Internal Assessment should be frequent, cover all domains of learning and used to provide feedback to improve learning; it should also cover professionalism and communication skills. The Internal Assessment should be conducted in theory and practical/clinical examination.

Quarterly assessment during the MD training should be based on:

1. **Journal based / recent advances learning**
2. **Patient based /Laboratory or Skill based learning**
3. **Self directed learning and teaching**

4. **Departmental and interdepartmental learning activity**
5. **External and Outreach Activities / CMEs**

The student to be assessed periodically as per categories listed in postgraduate student appraisal form (Annexure I).

SUMMATIVE ASSESSMENT, i.e., namely assessment at the end of the training

The summative examination would be carried out as per the Rules given in POSTGRADUATE MEDICAL EDUCATION REGULATIONS, 2000.

Post Graduate Examination will be in three parts:

1. **Thesis:**

   Every post graduate student shall carry out work on an assigned research project under the guidance of a recognised Post Graduate Teacher, the result of which shall be written up and submitted in the form of a Thesis. Work for writing the Thesis is aimed at contributing to the development of a spirit of enquiry, besides exposing the post graduate student to the techniques of research, critical analysis, acquaintance with the latest advances in medical science and the manner of identifying and consulting available literature.

   Thesis shall be submitted at least six months before the Theory and Clinical / Practical examination. The thesis shall be examined by a minimum of three examiners; one internal and two external examiners, who shall not be the examiners for Theory and Clinical examination. A post graduate student shall be allowed to appear for the Theory and Practical/Clinical examination only after the acceptance of the Thesis by the examiners.

2. **Theory Examination:**

   The examinations shall be organised on the basis of 'Grading'or 'Marking system' to evaluate and to certify post graduate student's level of knowledge, skill and competence at the end of the training. Obtaining a minimum of 50% marks in 'Theory' as well as 'Practical' separately shall be mandatory for passing examination as a whole. The examination for M.D. shall be held at the end of 3rd academic year. An academic term shall mean six month's training period**.**

   There will be 4 theory papers:

   Paper I: Basic Sciences related to Nuclear Medicine

   Paper II: Diagnostic Nuclear Medicine

   Paper III: Therapeutic Nuclear Medicine

   Paper IV: Recent advances in Nuclear Medicine

3. **Practical/Clinical and Oral Examination**

   Practical examination shall consist of carrying out special investigative techniques for diagnosis and therapy. Oral examination shall be comprehensive enough to test the post graduate student's overall knowledge of the subject.

   There shall be:

   1. One long case and two short cases.
   2. Two practicals consisting of one in basic science and one in clinical science.
   3. Spots
   4. Oral/viva-voce examination & scan reading

Recommended Reading: Books (latest edition)

1. *Neuro PET,* by Herholz
2. *Molecular anatomic Imaging,* by Von Schulthess
3. *Principles and Practice of Nuclear Medicine* ,by Paul, J. Early, D. Bruce Sodee
4. *Diagnostic Nuclear Medicine,* by Sandler and Gottchalk
5. *Nuclear Medicine in Clinical Diagnosis and Treatment,* by Ell and Gambhir
6. *Positron Emission Tomography,* by Valk, Bailey, Townsend
7. *Practical FDG Imaging A teaching File,* by Debelke, Martin, Patton, Sandler.
8. *Functional Cerebral SPECT and PE Imaging*
9. *CT and MR Imaging of the whole body,* Haaga, Lanzieri, Gilkeson
10. *Multidetector CT : Principle Techniques and Clinical Applications,* by Fishman Jeffrey *Normal Lymph node Topography*
11. *CT atlas,* by Richter Feyerabind

Journals

03 international Journals and 02 national (all indexed) journals

Annexure I

Postgraduate Students Appraisal Form Pre / Para /Clinical Disciplines

Name of the Department/Unit :

Name of the PG Student :

Period of Training : FROM……TO……

Sr. No.	PARTICULARS	Not Satisfactory	Satisfactory	More Than Satisfactory	Remarks
		1 2 3	4 5 6	7 8 9	
1.	Journal based / recent advances learning				
2.	Patient based /Laboratory or Skill based learning				
3.	Self directed learning and teaching				
4.	Departmental and interdepartmental learning activity				
5.	External and Outreach Activities / CMEs				
6.	Thesis / Research work				
7.	Log Book Maintenance				

Publications Yes/ No

Remarks* _____

_____

_____

***REMARKS: Any significant positive or negative attributes of a postgraduate student to be mentioned. For score less than 4 in any category, remediation must be suggested. Individual feedback to postgraduate student is strongly recommended.**

SIGNATURE OF ASSESSEE SIGNATURE OF CONSULTANT SIGNATURE OF HOD

MODEL PAPER

MD20301 **NM-I**

MD Examination Month, Year
NUCLEAR MEDICINE

Paper- I

Basic Sciences related to Nuclear Medicine

Time: Three Hours
Maximum Marks: 100

Attempt all questions
All the parts of one question should be answered at one place in sequential order.
Draw diagrams wherever necessary

Q1. What are the various methods of production of radionuclides? Explain in detail (along with a diagram) principles and applications of cyclotron. 20

Q2. Write on 2 x 15 = 30

a. Enumerate and explain the methods of radioactive decay, along with diagrammatic representation.

b. Explain the principles of radiation safety, Enumerate radiation monitoring devices, ICRP safety limits and explain in detail the personnel monitoring devices.

Q3. Write short notes on 5 x 10 = 50

a. Properties of various PET detectors.

b. Photoelectron effects and Compton scattering.

c. Enumerate mechanism of localization of radiopharmaceuticals, with clinical application of each type.

d. SPECT analogues of PET radiopharmaceuticals.

e. Enumerate various filters in image reconstruction, along with examples of its clinical application.

MODEL PAPER

MD20302 **NM-II**

MD Examination Month, Year

NUCLEAR MEDICINE

Paper- II

Diagnostic Nuclear Medicine

Time: Three Hours
Maximum Marks: 100

Attempt all questions
All the parts of one question should be answered at one place in sequential order.
Draw diagrams wherever necessary

Q1. Recent ATA guidelines for management of thyroid nodules and differentiated thyroid cancer. 20

Q2. Write on 2 x 15 = 30

I a. Assessment of myocardial viability - enumerate different techniques and where each stand in the management protocol.

b. In the following clinical scenario - 45yrs male, diabetic, hypertensive, known case of CAD (CAG: RCA-99% occlusion; LAD-99% occlusion; LCx-30% plaque), EF=20%- how viability assessment would impact the management protocol.

II a. Define techniques of infection imaging.

b. Evaluate a 48yrs male with h/o DM since 20yrs and ulceration on the sole since almost a month

Q3. Write short notes on 5 x 10 = 50

a. Deconvolution analysis and its clinical utility.

b. Evaluation of neck nodule with elevated serum calcium and PTH levels.

c. Role of SPECT imaging in epilepsy.

d. Interventions in GI nuclear scintigraphy

e. Modified PIOPED criterion for imaging for pulmonary embolism - intermediate and high risk.

MODEL PAPER

MD20303 **NM-III**

MD Examination Month, Year

NUCLEAR MEDICINE

Paper- III

Therapeutic Nuclear Medicine

Time: Three Hours
Maximum Marks: 100

Attempt all questions
All the parts of one question should be answered at one place in sequential order.
Draw diagrams wherever necessary

Q1. Write in details about role of NM and techniques in radioembolization of malignant liver lesions. Mention the clinical scenarios where this is indicated and contraindicated. 20

Q2. Write on 2 x 15 = 30

a. Peptide receptor RNT in NE tumors - indications, contraindications and procedure in detail.

b. RNT with 1131 for 'Thyroid Carcinoma - rationale for using 1131, recommendations (for localized, metastatic, recurrent disease) and dosages recommended.

Q3. Write short notes on 5 x 10 = 50

a. Enumerate the favorable properties of various radioisotopes that can be exploited for their usage for RNT along with examples.

b. RNT for benign thyroid diseases.

c. Radiation synovectomy - radioisotopes used with rationale; indications and contraindications.

d. Dosimetry in RNT - rationale and techniques.

e. Radioimmunotherapy for lymphoma - indications, limitations and RP used.

MODEL PAPER

MD20304 **NM-IV**

MD Examination Month, Year

NUCLEAR MEDICINE

Paper- IV

Recent advances in Nuclear Medicine

Time: Three Hours
Maximum Marks: 100

Attempt all questions
All the parts of one question should be answered at one place in sequential order.
Draw diagrams wherever necessary

Q1. Writes notes on 10x10=100

a. RNT for Ca Prostate

b. Brain scintigraphy in Parkinson's and Alzheimer's Disease - newer techniques.

c. Hybrid PET/MRI systems

d. RN imaging for detection of cardiac amyloidosis

e. Digital PET CT - principle and its pros and cons.

f. PET CT in management of differentiated thyroid carcinoma and its comparison with existing techniques.

g. RIT in Lung Carcinoma

h. Non FDG PET tracers in oncology for diagnosis

i. 18F-NaF Imaging - Techniques and clinical application

j. Recent advances in detecting Triple Vessel Disease - using PET and SPECT radioisotopes.