Jawaharlal Institute of Postgraduate Medical Education & Research

(JIPMER)

Puducherry

BSc Nuclear Medicine Technology

CURRICULUM

2021

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This curriculum was approved at the 16th meeting of the Standing Academic Committee held on September 21, 2021, and will be applicable for students joining BSc (Allied Health Sciences) – Nuclear Medicine Technology from the academic year 2021-22. The curriculum document was prepared based on the model curricula for allied health sciences courses issued by the Ministry of Health and Family Welfare, Government of India.

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About JIPMER

Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry (JIPMER) under Government of India since the year 1956, is one of the leading Medical Institutions of India. Spread over a sprawling 195-acre campus in an urban locale of Puducherry (formerly Pondicherry), JIPMER is 170 kms by road from Chennai.

JIPMER has been declared as an "Institution of National Importance" by an Act of Parliament, JIPMER, Puducherry, Act, 2008. A copy of the Act was Gazette notified on 14-7-2008 to enforce this Act. Prior to this, the Institute was functioning under the administrative control of Directorate General of Health Services, Ministry of Health and Family Welfare, New Delhi. The Institution is now empowered to award Medical Degrees under the clauses 23 & 24 of the said Act. Such Degrees shall be deemed to be included in the schedules to the respective Acts governing Medical Council of India/National Medical Commission, Indian Nursing Council, and Dental Council of India, entitling the holders to the same privileges as those attached to the equivalent awards from the recognized Universities of India.

JIPMER imparts Undergraduate (UG), Postgraduate (PG) and Super Specialty Medical Training through a large hospital complex (JIPMER Hospital) and a Nursing College. Some of the courses offered are MBBS, BSc, MSc, MD, MS, DM, and MCh courses. Full-time Ph.D. programs are available in several disciplines.

About the Department of Nuclear Medicine

At JIPMER, Nuclear Medicine services started in the year 2010 with a SPECT/CT as part of the department of Radiotherapy. In the year 2015, the Department of Nuclear Medicine was officially made independent. The department has one SPECT, one SPECT/CT, one PET/CT, Thyroid uptake probe, well counters, and several ancillary equipment. More than 4,500 scans and procedures are performed annually. Out-patient radionuclide therapy is also offered. Radionuclide therapy (RNT) ward started functioning from March 2021 and offers radionuclide therapy services on in-patient basis.

COURSE DETAILS

Nomenclature: BSc (Allied Health Sciences) – Nuclear Medicine Technology

Introduction:

Nuclear medicine is a unique branch of medicine that offers both diagnostic and therapeutic services for various indications. It involves the administration of very small amounts of unsealed radiopharmaceuticals (radiotracers) to study the function of various organs systems and in the diagnosis and follow-up of cancer patients. Radiopharmaceuticals are also used to treat various disease conditions.

Objectives of the course:

The aim of the course is to impart appropriate knowledge and skills to work closely with nuclear medicine physicians and participate in the daily operation of the nuclear medicine department. At the end of the course, a B.Sc. (AHS) Nuclear Medicine Technology graduate will be able to:

- function as a Nuclear Medicine Technologist as part of a Nuclear Medicine team and assist in diagnostic and therapeutic nuclear medicine procedures
- plan, assist in obtaining necessary permissions, procure, store, prepare, and administer radiopharmaceuticals to patients following the correct procedures under the guidance of a Nuclear Medicine Physician
- perform diagnostic scan and non-imaging procedures on patients as per the established recent guidelines
- manage and ensure good maintenance of the various nuclear medicine equipment
- adhere to the regulatory requirements in the handling of radionuclides, including safe waste disposal
- contribute to the planning of nuclear medicine installations and procurement of equipment

First phase: one year

In addition to the subjects of foundation course, Anatomy, and Physiology, students will learn the basic concepts in areas such as Biochemistry, Pathology, radiation physics, mathematics, and statistics.

Second phase: one year

In the Second phase, the students will learn the concepts of radiation detection and the concepts behind formation of images. This includes gaining knowledge about basic instrumentation of radiation detection devices such as spectrometer and gamma camera. They will learn about the production of radionuclides that are used for diagnosis and therapy. They will be trained to label radiopharmaceuticals and perform their quality assessment. The students will learn about the effects of radiation on human body and how radiation exposure can be kept to a minimum.

Third phase: one year

In the Third phase, the students will learn to perform various diagnostic and therapeutic nuclear medicine procedures. They will also be trained in designing a new nuclear medicine facility, procurement of equipment, and following regulatory requirements to operate such a facility.

Internship: one year

Internship of one year is compulsory. The interns will be given hands-on training in diagnostic and therapeutic procedures. They will also take part in the radiation safety and protection activities of the department. They will have one month posting in Radiodiagnosis and 15 days in Cardiology.

Expectations from the future graduate

A Nuclear medicine team consists primarily of Nuclear Medicine Physicians, Technologists, and Nurses. The members should work as a team and function in a coordinated manner to achieve productive results. Technologists form an integral and indispensable part of the team and work in union alongside nuclear medicine physicians, nurses and in some cases, medical physicists.

The Society of Nuclear medicine and molecular imaging (SNMMI) has outlined the principles of Nuclear Medicine Technologist code of ethics approved on June 7, 2013 and these principles exemplify the role and the duties of a Nuclear Medicine Technologist graduate:

Principle 1 The nuclear medicine technologist will provide services with compassion and respect for the dignity of the individual and with the intent to provide the highest quality of patient care.

Principle 2 The nuclear medicine technologist will provide care without discrimination regarding the nature of the illness or disease, gender, race, religion, sexual preference, or socioeconomic status of the patient.

Principle 3 The nuclear medicine technologist will maintain strict patient confidentiality in accordance with state and federal regulations.

Principle 4 The nuclear medicine technologist will comply with the laws, regulations, and policies governing the practice of nuclear medicine.

Principle 5 The nuclear medicine technologist will continually strive to improve his or her knowledge and technical skills.

Principle 6 The nuclear medicine technologist will not engage in fraud, deception, or criminal activities.

Principle 7 The nuclear medicine technologist will be an advocate for his or her profession.

Available postgraduate programmes in India

Master of Science in Nuclear Medicine and Nuclear Medicine Technology courses are available in 7 institutions including AIIMS, New Delhi, Panjab University (and PGIMER), Chandigarh, Radiation Medicine Centre, Mumbai, and SGPGIMS, Lucknow. Complete list of Nuclear Medicine Technology courses is available at https://www.aerb.gov.in/images/PDF/NuclearMedicine/RSD2.pdf

Job profile

A qualified Nuclear Medicine Technologist typically performs the following roles (but not limited to) in a Nuclear Medicine department:

1. Elution of radionuclide generator, labelling of radiopharmaceuticals, quality control, and dispensing of radiopharmaceutical doses for administration.
2. Scheduling of patients, providing information, and their preparation for diagnostic studies or therapy.
3. Perform diagnostic studies including scan acquisition, image processing, image printing and other such activities as advised by a nuclear medicine physician.
4. Preparation of patients for treatment, calculation of administered dose, dispensing radiopharmaceutical, monitoring radiation levels and ensuring radiation safety measures.
5. Performing quality control of equipment and ensuring their working condition.
6. Maintenance of all records pertaining to equipment, radionuclides, personnel, and radiation safety.
7. When appointed, perform the duties of radiological safety officer.

Eligibility for the course:

- The Applicant should be an **Indian National.**
- He/she should have completed **17 years** at the time of application cut-off date.
- There is **no upper age limit.**

The applicants should have passed the qualifying examinations in the manner mentioned below:

- The Higher / Senior Secondary Examination or the Indian School Certificate Examination which is equivalent to 10+2 Higher/Senior Secondary Examination after a period of 12 years study, the last two years of such study comprising Physics, Chemistry, Biology/ Botany & Zoology (which shall include practical tests in these subjects) and with English as a subject.
- The applicant must have passed in the subjects of Physics, Chemistry, Biology/Botany & Zoology and English individually and must have obtained a minimum of 50% marks

taken together in Physics, Chemistry, Biology/Botany & Zoology at the qualifying examination

- Candidates belonging to the Scheduled Castes/Scheduled Tribe or Other Backward Classes must have obtained a minimum of 40% marks in the subjects of Physics, Chemistry, Biology / Botany & Zoology taken together in the qualifying examination.
- For PwD candidates in general and EWS categories, the minimum marks in Physics, Chemistry, Biology/ Botany & Zoology taken together in the qualifying examination is 45%.

Candidates intake per year:

Five candidates will be admitted to the course every year. There is no provision for sponsored / nominated candidates.

Duration of the course

4 years (48 months) duration including 3 years of classes and one year of compulsory internship.

Medium of instruction:

English

Vacation:

Students will be eligible for 4 weeks of vacation in summer and 2 weeks in winter.

Subject details:

Phase	Paper	Title of the paper
I	I	Foundation course (T & P)
	II	Anatomy and Physiology (T & P)
	III	Pathology and Microbiology (T)
	IV	Preparatory concepts in Nuclear Medicine (T & P)
II	I	Instrumentation and Quality control of Nuclear Medicine Equipment (T & P)
	II	Radiochemistry and Radiopharmacy (T & P)
	III	Radiobiology and Radiation Protection (T & P)
III	I	Diagnostic Nuclear Medicine Techniques (T & P)
	II	Therapeutic Nuclear Medicine Techniques and Radiation dosimetry (T & P)
	III	Recent advances, Planning, and Regulatory requirements (T & P)
	Internship	

T- Theory, P- Practical

SYLLABUS

Phase I

Paper I: Foundation course

Theory:

Introduction to National Healthcare System

The course provides the students a basic insight into the main features of Indian health care delivery system and how it compares with the other systems of the world. Topics to be covered under the subject are as follows:

1. Introduction to healthcare delivery system

   a. Healthcare delivery system in India at primary, secondary and tertiary care
   b. Community participation in healthcare delivery system
   c. Health system in developed countries.
   d. Private Sector
   e. National Health Mission
   f. National Health Policy
   g. Issues in Health Care Delivery System in India

2. National Health Programme- Background objectives, action plan, targets, operations, achievements, and constraints in various National Heath Programme.

3. Introduction to AYUSH system of medicine

   a. Introduction to Ayurveda.
   b. Yoga and Naturopathy
   c. Unani
   d. Siddha
   e. Homeopathy
   f. Need for integration of various system of medicine

4. Health scenario of India- past, present, and future

5. Demography & Vital Statistics-

   a. Demography – its concept
   b. Vital events of life & its impact on demography
   c. Significance and recording of vital statistics
   d. Census & its impact on health policy

6. Epidemiology

   a. Principles of Epidemiology
   b. Natural History of disease
   c. Methods of Epidemiological studies

d. Epidemiology of communicable & non-communicable diseases, disease transmission, host defence immunizing agents, cold chain, immunization, disease monitoring and surveillance.

Medical terminologies and record keeping

This course introduces the elements of medical terminology. Emphasis is placed on building familiarity with medical words through knowledge of roots, prefixes, and suffixes. Topics include origin, word building, abbreviations and symbols, terminology related to the human anatomy, reading medical orders and reports, and terminology specific to the student's field of study. Spelling is critical and will be counted when grading tests.25 Topics to be covered under the subject are as follows:

1. Derivation of medical terms.
2. Define word roots, prefixes, and suffixes.
3. Conventions for combined morphemes and the formation of plurals.
4. Basic medical terms.
5. Form medical terms utilizing roots, suffixes, prefixes, and combining roots.
6. Interpret basic medical abbreviations/symbols.
7. Utilize diagnostic, surgical, and procedural terms and abbreviations related to the integumentary system, musculoskeletal system, respiratory system, cardiovascular system, nervous system, and endocrine system.
8. Interpret medical orders/reports.
9. Data entry and management on electronic health record system.

Basic computers and information science

The students will be able to appreciate the role of computer technology. The course has focus on computer organization, computer operating system and software, and MS windows, Word processing, Excel data worksheet and PowerPoint presentation. Topics to be covered under the subject are as follows:

1. Introduction to computer: Introduction, characteristics of computer, block diagram of computer, generations of computer, computer languages.

2. Input output devices: Input devices (keyboard, point and draw devices, data scanning devices, digitizer, electronic card reader, voice recognition devices, vision-input devices), output devices (monitors, pointers, plotters, screen image projector, voice response systems).

3. Processor and memory: The Central Processing Unit (CPU), main memory.

4. Storage Devices: Sequential and direct access devices, magnetic tape, magnetic disk, optical disk, mass storage devices.

5. Introduction of windows: History, features, desktop, taskbar, icons on the desktop, operation with folder, creating shortcuts, operation with windows (opening, closing, moving, resizing, minimizing, and maximizing, etc.).

6. Introduction to MS-Word: introduction, components of a word window, creating, opening and inserting files, editing a document file, page setting and formatting the text, saving the document, spell checking, printing the document file, creating and editing of table, mail merge.

7. Introduction to Excel: introduction, about worksheet, entering information, saving workbooks and formatting, printing the worksheet, creating graphs.

8. Introduction to power-point: introduction, creating and manipulating presentation, views, formatting and enhancing text, slide with graphs.

9. Introduction of Operating System: introduction, operating system concepts, types of operating system.

10. Computer networks: introduction, types of networks (LAN, MAN, WAN, Internet, Intranet), network topologies (star, ring, bus, mesh, tree, hybrid), components of network.

11. Internet and its Applications: definition, brief history, basic services (E-Mail, File Transfer Protocol, telnet, the World Wide Web (WWW)), www browsers, use of the internet.

12. Application of Computers in clinical settings.

Medical law and ethics

Legal and ethical considerations are firmly believed to be an integral part of medical practice in planning patient care. Advances in medical sciences, growing sophistication of the modern society's legal framework, increasing awareness of human rights and changing moral principles of the community at large, now result in frequent occurrences of healthcare professionals being caught in dilemmas over aspects arising from daily practice.26

Medical ethics has developed into a well based discipline which acts as a "bridge" between theoretical bioethics and the bedside. The goal is "to improve the quality of patient care by identifying, analysing, and attempting to resolve the ethical problems that arise in practice".26 Doctors are bound by, not just moral obligations, but also by laws and official regulations that form the legal framework to regulate medical practice. Hence, it is now a universal consensus that legal and ethical considerations are inherent and inseparable parts of good medical practice across the whole spectrum. Few of the important and relevant topics that need to focus on are as follows:

1. Medical ethics - Definition - Goal - Scope

2. Introduction to Code of conduct

3. Basic principles of medical ethics – Confidentiality

4. Malpractice and negligence - Rational and irrational drug therapy

5. Autonomy and informed consent - Right of patients

6. Care of the terminally ill- Euthanasia

7. Organ transplantation

8. Medico legal aspects of medical records – Medico legal case and type- Records and document related to MLC - ownership of medical records - Confidentiality Privilege

communication - Release of medical information - Unauthorized disclosure - retention of medical records - other various aspects.

9. Professional Indemnity insurance policy

10. Development of standardized protocol to avoid near miss or sentinel events

11. Obtaining an informed consent.

Communication and soft skills

Major topics to be covered under Communication course –

1. Basic Language Skills: Grammar and Usage.

2. Business Communication Skills. With focus on speaking - Conversations, discussions, dialogues, short presentations, pronunciation.

3. Teaching the different methods of writing like letters, E-mails, report, case study, collecting the patient data etc. Basic compositions, journals, with a focus on paragraph form and organization.

4. Basic concepts & principles of good communication

5. Special characteristics of health communication

6. Types & process of communication

7. Barriers of communication & how to overcome

Introduction to Quality and patient safety

1. Quality assurance and management - The objective of the course is to help students understand the basic concepts of quality in health Care and develop skills to implement sustainable quality assurance program in the health system.

a. Concepts of Quality of Care

b. Quality Improvement Approaches

c. Standards and Norms

d. Quality Improvement Tools

e. Introduction to NABH guidelines

2. Basics of emergency care and life support skills - Basic life support (BLS) is the foundation for saving lives following cardiac arrest. Fundamental aspects of BLS include immediate recognition of sudden cardiac arrest (SCA) and activation of the emergency response system, early cardiopulmonary resuscitation (CPR), and rapid defibrillation with an automated external defibrillator (AED). Initial recognition and response to heart attack and stroke are also

considered part of BLS. The student is also expected to learn about basic emergency care including first aid and triage. Topics to be covered under the subject are as follows:

a. Vital signs and primary assessment

b. Basic emergency care – first aid and triage

c. Ventilations including use of bag-valve-masks (BVMs)

d. Choking, rescue breathing methods

e. One- and Two-rescuer CPR

f. Using an AED (Automated external defibrillator).

g. Managing an emergency including moving a patient

At the end of this topic, focus should be to teach the students to perform the manoeuvres in simulation lab and to test their skills with focus on airways management and chest compressions. At the end of the foundation course, each student should be able to perform and execute/operate on the above-mentioned modalities.

3. Bio medical waste management and environment safety- The aim of this section will be to help prevent harm to workers, property, the environment, and the general public. Topics to be covered under the subject are as follows:

a. Definition of Biomedical Waste

b. Waste minimization

c. BMW – Segregation, collection, transportation, treatment, and disposal (including colour coding)

d. Liquid BMW, Radioactive waste, Metals / Chemicals / Drug waste

e. BMW Management & methods of disinfection

f. Modern technology for handling BMW

g. Use of Personal protective equipment (PPE)

h. Monitoring & controlling of cross infection (Protective devices)

4. Infection prevention and control - The objective of this section will be to provide a broad understanding of the core subject areas of infection prevention and control and to equip AHPs with the fundamental skills required to reduce the incidence of hospital acquired infections and improve health outcomes. Concepts taught should include –

a. Evidence-based infection control principles and practices [such as sterilization, disinfection, effective hand hygiene and use of Personal protective equipment (PPE)],

b. Prevention & control of common healthcare associated infections,

c. Components of an effective infection control program, and

d. Guidelines (NABH and JCI) for Hospital Infection Control

5. Antibiotic Resistance-

a. History of Antibiotics

b. How Resistance Happens and Spreads

c. Types of resistance- Intrinsic, Acquired, Passive

d. Trends in Drug Resistance

e. Actions to Fight Resistance

f. Bacterial persistence

g. Antibiotic sensitivity

h. Consequences of antibiotic resistance

i. Antimicrobial Stewardship- Barriers and opportunities, Tools and models in hospitals

6. Disaster preparedness and management- The objective of this section will be to provide knowledge on the principles of on-site disaster management. Concepts to be taught should include-

a. Fundamentals of emergency management,

b. Psychological impact management,

c. Resource management,

d. Preparedness and risk reduction,

e. Key response functions (including public health, logistics and governance, recovery, rehabilitation, and reconstruction), information management, incident command and institutional mechanisms.

Professionalism and values

The module on professionalism will deliver the concept of what it means to be a professional and how a specialized profession is different from a usual vocation. It also explains how relevant professionalism in terms of healthcare system is and how it affects the overall patient environment.

1. Professional values- Integrity, Objectivity, Professional competence and due care, Confidentiality

2. Personal values- ethical or moral values

3. Attitude and behaviour- professional behaviour, treating people equally

4. Code of conduct, professional accountability and responsibility, misconduct

5. Differences between professions and importance of team efforts

6. Cultural issues in the healthcare environment

Research Methodology and Biostatistics

The objective of this module is to help the students understand the basic principles of research and methods applied to draw inferences from the research findings.

1. Introduction to research methods
2. Identifying research problem
3. Ethical issues in research
4. Research design
5. Basic Concepts of Biostatistics
6. Types of Data
7. Research tools and Data collection methods
8. Sampling methods
9. Developing a research proposal

Principles of Management

The course is intended to provide knowledge about the basic principles of Management.

1. Introduction to management
2. Strategic Management
3. Foundations of Planning
4. Planning Tools and Techniques
5. Decision Making, conflict and stress management
6. Managing Change and Innovation
7. Understanding Groups and Teams
8. Leadership
9. Time Management
10. Cost and efficiency

Community orientation and clinical visit

The objective of this section of the foundation course is to sensitize potential learners with essential knowledge; this will lay a sound foundation for their learning across the under-graduate program and across their career. Innovative teaching methods should be used to ensure the attention of a student and make them more receptive such as group activities, interactive fora, role plays, and clinical bed-side demonstrations.

1. The community orientation and clinical visit will include visit to the entire chain of healthcare delivery system -Sub centre, PHC, CHC, SDH, DH and Medical College, private hospitals, dispensaries, and clinics.

2. The student will also be briefed regarding governance at village level including interaction and group discussion with village panchayat and front-line health workers.

3. Clinical visit to their respective professional department within the hospital.

Practical:

Fundamentals of computers

1. Learning to use MS office: MS word, MS PowerPoint, MS Excel

2. To install different software.

3. Data entry efficiency

Paper II: Anatomy and Physiology

Gross anatomy and Histology

Theory:

General Anatomy:

Introduction – Anatomical terms, position, movements; epithelium – classification, structure & examples; Tissues – classification and structure; skin – structure, thick and thin skin; cartilage – types, structure, hyaline, elastic, and white fibrocartilage; bones – classification, structure, growth; muscles - classification & structure; glands - classification & structure.

Musculoskeletal system:

Axial and appendicular skeleton – muscle groups and regions muscles with action.

Cardiovascular and lymphatic system:

Structure of pericardium, heart & major blood vessels – arteries, veins, and lymphatic system – classification and structure of lymphoid organs – thymus, spleen, lymph node, tonsil, and major lymphatic vessels.

Respiratory system:

Parts of respiratory system, structure of external nose, paranasal air sinuses, nasal cavity, nasopharynx, larynx, trachea, pleura, lungs & diaphragm.

Gastrointestinal system:

Parts of gastrointestinal system, salivary glands, oral cavity, oropharynx and laryngopharynx, esophagus, stomach, small intestine, large intestine, liver, gallbladder, extrahepatic biliary apparatus, and pancreas.

Excretory system:

Parts of excretory system – structure of kidney, ureter, urinary bladder & urethra.

Male and female reproductive systems:

Structure & parts of male reproductive system, external genitalia, testis, epididymis, vasdeferens, seminal vesicle and prostate.

Structure & parts of female reproductive system, uterus, ovary, fallopian tubes, and mammary gland

Endocrine system:

Location & structure of thyroid, parathyroid, pituitary, adrenal glands.

Special senses:

` Structure of eyeball, external, middle & internal ear, and papillae of tongue.

Nervous system:

Neuron, neuroglia, classification, autonomic nervous system, meninges, parts of brain, cerebrum, cerebellum, basal nuclei, limbic system, thalamus, hypothalamus, spinal cord, circulation of cerebrospinal fluid.

Histology:

General histology:

Microscopy – Types of microscopes, parts of microscope, cleaning, and maintenance of microscope.

Microscopic features of

1. Cartilages
   1.1 Hyaline,
   1.2 Elastic
   1.3 White fibro cartilages
2. Bones
   2.1 Longitudinal section of compact bone
   2.2 Cross section of compact bone
3. Muscles
   3.1 Skeletal muscle
   3.2 Cardiac muscle
4. Glands
   4.1 Serous gland
   4.2 Mucous gland
   4.3 Mixed gland
5. Blood vessels
   5.1 Medium sized artery
   5.2 Large sized artery
   5.3 Medium sized vein
   5.4 Large sized vein
6. Nervous tissue
   6.1 Peripheral nerve H & E stain
   6.2 Peripheral nerve Osmic acid stain
   6.3 Dorsal root (spinal) ganglia
   6.4 Autonomic ganglia
7. Lymphoid organs
   7.1 Thymus
   7.2 Lymph node
   7.3 Spleen
   7.4 Tonsil
8. Skin
   8.1 Thick skin
   8.2 Thin skin

Practical:

Anatomy (Gross anatomy and Histology)

1. Demonstration of bones
2. Demonstration of various parts of body
3. Demonstration of parts of digestive system
4. Demonstration of parts of respiratory system
5. Demonstration of parts of reproductive system
6. Demonstration of parts of excretory system
7. Demonstration of various parts of circulatory system
8. Demonstration of various parts of nervous system
9. General histology slides

Textbooks Recommended (Latest edition):

General anatomy:

1. Handbook of General Anatomy – B.D. Chaurasia - CBS Publishers

Systemic Anatomy:

1. Textbook of Anatomy – Vishram Singh – Elsevier
2. B.D. Chaurasia's Human Anatomy – CBS Publishers
3. Manipal Manual of Anatomy for Allied Health Science Courses

Histology:

1. Textbook of Human Histology: With Color Atlas 3D Illustrations – Dr. Yogesh Sontakke
2. Textbook of Histology - A Practical guide – Dr. J. P Gunasegaran
3. Di Fiore's Atlas of Histology – Eroschenko – Lippincott Williams & Wilkins

Reference textbook:

Gray's Anatomy: The Anatomical Basis of Clinical Practice – Susan Standring – Elsevier

Physiology

Theory:

1. **General Physiology**
   a. Principle of homeostasis
   b. Cell membrane, cell organelles, intercellular junctions
   c. Transport across cell membrane
   d. Body fluids: Classification of body fluid compartments, ionic composition, measurement
   e. Resting membrane potential

2. **Blood**
   a. Composition of blood
   b. Plasma proteins: classification and functions
   c. RBC: development, morphology, counts, functions and dysfunctions
   d. Hemoglobin: types, structure, synthesis, function, degradation, anemia
   e. WBC: development, classification, morphology, counts, functions and dysfunctions
   f. Immunity: definition, classification, Innate, Cellular and Humoral Immunity
   g. Platelets: morphology, counts, development, functions and dysfunctions
   h. Blood coagulation: clotting factors, mechanism, dysfunctions
   i. Anticoagulants
   j. Blood grouping: classification, cross matching, blood transfusion, Rh factor and incompatibility
3. **Nerve**
   a. Structure, function, classification of neurons
   b. Neuronal action potential: ionic basis and properties
   c. Conduction of nerve impulses
   d. Nerve Injuries
   e. Neuromuscular junction: structure, mechanism of transmission & applied aspects
4. **Muscle**
   a. Structure of skeletal muscle & sarcotubular system
   b. Mechanism of contraction and relaxation of skeletal muscle
   c. Isotonic and isometric contraction
   d. Properties of skeletal muscle
   e. Smooth muscle: structure, properties, and mechanism of contraction
   f. Differences between skeletal, smooth, and cardiac muscles
5. **Autonomic nervous system**
   a. Divisions and functions
6. **Gastrointestinal (GI) system**
   a. Functional anatomy of GIT
   b. Gastrointestinal hormones
   c. Principles & Functions of GI secretions, applied aspects
   d. Movements of GIT, applied aspects

7. **Endocrine system**

Hormones, actions, and dysfunctions of various endocrine glands:

   a. Hypothalamus
   b. Pituitary
   c. Thyroid
   d. Parathyroid and hormones involved in calcium homeostasis
   e. Adrenal gland
   f. Endocrine pancreas
8. **Reproductive System**
   a. Male and female gametogenesis

b. Structure and function of male reproductive system
c. Structure of female reproductive system, menstrual cycle, pregnancy, parturition, lactation
d. Contraceptives

9. Kidney

a. Structure & function of kidney, structure of nephron, composition of urine
b. Glomerular filtration rate: definition, values, regulation and measurement
c. Mechanism of urine formation: tubular functions, concentration of urine, acidification of urine
d. Micturition reflex
e. Diuretics
f. Dialysis

10. Cardiovascular system

a. Functional anatomy of heart
b. Circulatory system: arterial, venous, capillary circulation
c. Structure and properties of cardiac muscle
d. Electrophysiology of heart and conduction of impulse
e. ECG: waveforms and physiological basis
f. Cardiac cycle, heart sounds, Jugular venous pulse
g. Stroke volume, heart rate, cardiac output – definition, normal values and their regulation
h. Blood pressure and regulation
i. Coronary circulation
j. Lymphatic circulation
k. Applied aspects: shock, hypertension, hypotension, tachycardia, bradycardia, heart failure

11. Respiratory system

a. Functional anatomy of respiratory system
b. Mechanics of breathing, lung volumes and capacities, compliance, surfactant
c. Alveolar ventilation, dead space, pulmonary circulation, ventilation-perfusion ratio
d. Diffusion and gas exchange
e. Transport of oxygen and carbon dioxide
f. Brief account of respiratory regulation
g. Acclimatization, definition & types of hypoxia, oxygen therapy, cyanosis, asphyxia.
h. Methods of artificial respiration

12. Central nervous system

a. Parts and functions of brain and spinal cord
b. Sensory system: receptors and ascending pathways
c. Motor system: motor neurons, motor units, muscle spindle, stretch reflex, and descending tracts with emphasis on corticospinal tract
d. Cerebellum- functional anatomy, functions, and dysfunctions

e. Basal ganglia- functional anatomy, functions, and dysfunctions
f. Functions of hypothalamus
g. Functions of Thalamus
h. Types of sleep and EEG
i. Cerebrospinal fluid
j. Higher functions: types of memory, centers of speech, types of aphasia in brief, Cerebral cortex-lobes and functions
k. Blood-brain barrier

13. Special senses

a. Vision: Components of visual apparatus, visual acuity, color vision, accommodation, errors of refraction, visual pathway, pupillary reflexes
b. Hearing: External, middle ear, inner ear and their functions, auditory pathway, hearing tests.
c. Taste – receptors and pathway
d. smell: receptors and pathway

14. Integrative Physiology

a. Structure and functions of skin
b. Regulation of temperature

Practical: Physiology

1. Hematology

a. Methods of collection of blood
b. Microscopy
c. Haemocytometry
d. Total RBC count
e. Estimation of haemoglobin
f. Calculation of blood indices
g. Demonstration of osmotic fragility of red blood cells
h. Determination of ESR
i. Total leucocyte count
j. Absolute eosinophil count
k. Peripheral blood smear
l. Differential leukocyte count
m. Arneth count
n. Determination of blood group
o. Bleeding time, Clotting time
p. Demonstration of reticulocyte count
q. Demonstration of platelet count
r. Demonstration of PCV

2. Clinical

a. General physical examination
b. Clinical examination of Radial pulse
c. Determination of blood pressure
d. Recording of Electrocardiogram
e. Examination of cardiovascular system
f. Examination of respiratory system
g. Demonstration of spirometry
h. Determination of vital capacity and effect of posture of vital capacity
i. Examination of sensory system
j. Examination of motor system
k. Visual acuity
l. Color vision
m. Pupillary reflexes
n. Perimetry
o. Tests of hearing
p. Mosso'sergography

Textbooks recommended: (Latest edition)

1. Textbook of Medical Physiology by G.K. Pal (Theory)
2. Textbook of Practical Physiology by G.K. Pal & Pravati Pal (Practical)

Teaching learning methodology:

The course content in Physiology will be covered by:

1. Interactive Lectures
2. Group Discussions
3. Practical classes & demonstrations
4. Seminars
5. Assignments

Paper III: Pathology and Microbiology

Pathology

The Pathology syllabus introduces the principles of **Pathology** with emphasis on applied aspects of Pathology particularly in the following areas:

1. Collection and dispatch of specimens for routine pathological investigations
2. Common routine pathology tests
3. General concepts of Pathology
4. Laboratory diagnosis of common pathological conditions
5. Systemic Pathology
6. Applied Surgical Pathology, cytopathology, hematopathology, renal pathology and neuropathology

Theory:

1. Adaptations, cell injury and repair

a. Hyperplasia,
b. hypertrophy,
c. atrophy,
d. metaplasia,
e. Necrosis and
f. Apoptosis

2. Acute and chronic inflammation

a. Cardinal signs of inflammation
b. Outcomes of acute inflammation
c. Chronic inflammation
d. Granulomatous inflammation
e. Acute phase proteins

3. Tissue repair, regeneration, and hemodynamic disorders

a. Cutaneous wound healing
b. Pathological aspects of repair
c. Hyperaemia and congestion
d. Thrombosis and Virchow triad
e. Embolism, infarction, and shock

4. Disorders of immune system

a. Types of hypersensitivity reactions
b. Autoimmune diseases

5. Neoplasia

a. Definition of neoplasia.
b. Differences between benign and malignant tumours

c. Metastasis
d. Carcinogenesis – causes

6. Applied general pathology related to transfusion medicine

a. ABO blood group & Rh system (terminologies)
b. Principles of blood grouping and cross matching
c. Shelf life of stored blood
d. Anticoagulants used for storing blood and temperature for storage

7. RBC, WBC, and bleeding disorders

a. Anaemia – definition and classification
b. Iron deficiency anaemia and haemolytic anaemia
c. Leukocytosis and leukaemia
d. Causes of splenomegaly
e. Thrombocytopenia and coagulation disorders
f. Phlebotomy, haemoglobin estimation, peripheral smear examination, bleeding time, PT and APTT

8. Disorders of GI tract, liver, biliary tract, and pancreas

a. Causes of peptic ulcer, carcinoma stomach, intestinal obstruction, acute appendicitis, and colonic carcinoma
b. Jaundice – classification based on pathophysiology
c. Cirrhosis – definition and causes
d. Hepatitis – types and mode of transmission
e. Portal hypertension and hepatic failure

9. Blood vessels, heart, and lung diseases

a. Risk factors for atherosclerosis and their classification
b. Hypertension – definition and causes
c. Varicose veins, thrombophlebitis and phlebothrombosis
d. Congenital heart disease and heart failure
e. Myocardial infarction and cor-pulmonale
f. Rheumatic heart disease
g. Chronic obstructive airway disease
h. Asthma, pneumonia, and lung carcinoma

10. The kidney and lower urinary tract, male and female genital tract

a. Acute and chronic renal failure
b. Nephrotic and nephritis syndrome
c. Acute tubular necrosis and urolithiasis
d. Carcinoma penis, testicular tumours, and prostatic hyperplasia
e. Endometriosis, adenomyosis and leiomyoma

11. Endocrine and nervous system

a. Diagnostic criteria, types, and complications of diabetic mellitus

b. Intracerebral, subarachnoid, and subdural haemorrhage
c. Meningitis and encephalitis
d. Epilepsy and CNS tumours

12. Applied Surgical Pathology & Cytopathology, renal pathology, and neuropathology

a. Histopathology techniques
b. Fine needle aspiration cytology and imprint cytology
c. Basic terminologies of surgical specimens
d. Urine analysis and renal biopsy
e. CSF cytology, nerve and muscle biopsy, squash cytology

Textbooks recommended (latest edition)**:**

1. Illustrated Pathology – McFarlen
2. Essentials of Rubin's Pathology
3. Basic Pathology by Robbins
4. General and systemic Pathology – Underwood and Cross

Teaching and Learning methodology

Mostly will be didactic lectures with tutorials.

Microbiology

The Microbiology syllabus introduces the principles of **Microbiology** with emphasis on applied aspects of Microbiology of infectious diseases particularly in the following areas

1. Universal and Standard precaution.
2. Collection and dispatch of specimens for routine microbiological investigations.
3. Common routine serological tests
4. General concept of infection
5. Common Bacteriological, Viral, Fungal, Parasitic infection and Laboratory diagnosis
6. Nosocomial infection
7. Biomedical waste management
8. Vaccine

Theory:

Introduction and Morphology

Introduction of microbiology, Classification of microorganisms, size, shape and structure of bacteria. Use of microscope in the study of bacteria.

Growth and Nutrition

Nutrition, Culture media, Types of medium with example and uses of culture media in diagnostic bacteriology, antimicrobial sensitivity test.

Sterilisation and Disinfection

Principles and use of equipment of sterilization namely Hot Air oven, Autoclave and serum inspissator. Pasteurization, Anti septic and disinfectants.

Immunology

Immunity, Types of Immunity, Vaccines, Types of Vaccine and immunization schedule. Principles and interpretation of commonly done serological tests namely Widal, VDRL, ASLO, ELISA, Rapid tests for HIV and HbsAg

Systematic Bacteriology

Morphology, diseases caused, laboratory diagnosis including specimen collection of the following bacteria (the classification, antigenic structure and pathogenicity are not to be taught) Staphylococci, Streptococci, Pneumococci, Gonococci, Meningococci, C. diphtheriae, Mycobacterium tuberculosis, Clostridium spp., Bacillus spp., Shigella spp., Salmonella spp., Escherichia coli, Klebsiella spp., Proteus spp., Vibrio cholera, Pseudomonas spp. & Spirochaetes

Parasitology

Morphology, life cycle, laboratory diagnosis of following parasites E. histolytica, Plasmodium spp., Tapeworms, Intestinal nematodes, Filariasis

Mycology

Morphology, diseases caused, laboratory diagnosis of following fungi. Candida, Cryptococcus, opportunistic fungi

Virology

General properties of viruses, diseases caused, lab diagnosis and prevention of following viruses, Herpes, Hepatitis, HIV, Rabies and Poliomyelitis

Hospital Infection

Causative agents, transmission methods, investigation, prevention and control Hospital infection, Universal precaution, Standard precaution

Principles and Practice Biomedical Waste Management

Applied Microbiology

Causative agents, Sample collection and Laboratory diagnosis
Gastrointestinal infections, Nosocomial infections, Urinary tract infections, Respiratory tract infections, Pyogenic Meningitis, Food borne infections, Vector borne infections, Blood borne infections, Aerosol borne infections.

Textbooks recommended (latest editions):

1. CP. Baveja. Textbook of Microbiology for nurses. Arya Publishing Company.
2. RL Ichhpujani, Rajesh Bhatia. Essentials of Medical Microbiology. Jaypee Brothers Medical Pub (p) Ltd.
3. Seema Sood. Microbiology for Nursing Students & Nurses. Elsevier India Pvt.Ltd.
4. Satish Gupte. Short Textbook of Medical Microbiology. Jaypee Brothers Medical Pub (p) Ltd.
5. CK Jayaram Paniker, Ananthanarayan R. Textbook of Microbiology for nurses. Publisher Universities Press (India) Limited.
6. B.S.Nagoba. Clinical Microbiology. Bi Publications Pvt Ltd.
7. Clint E Carter, Burton J Bogitsh, Thomas N Oeltmann. Human Parasitology. Publisher Elsevier India Pvt. Ltd.

Paper IV: Preparatory concepts in Nuclear Medicine

Theory:

Section A: Fundamental concepts in Nuclear Medicine

Applied Pharmacology

- General principles of Pharmacology - Introduction
    - Pharmacokinetics: Routes of drug delivery, biodistribution, factors that affect movement of drugs in the body
    - Pharmacodynamics: Mechanism of action of drugs in human body, factors that affect the action of drugs.
- Commonly used drugs in Nuclear Medicine: Mechanism of action, precautions, dosage, and adverse effects of Loop diuretics, Acetazolamide, Morphine, Aspirin, Captopril, Enalaprilat, Adenosine, dobutamine, Adrenaline (Epinephrine), Atropine, Isosorbide dinitrate, H2 receptor blockers (Ranitidine), Proton Pump inhibitors, Ursodeoxycholic acid, Phenobarbitone, Lugol's iodine, Thyroxine, Anti-thyroid drugs (Propylthiouracil, Thionamides), Potassium perchlorate, Sincalide (cholecystokinin), Trichlofos, and Bisphosphonates.

Applied Pathology

- Cellular pathology: Cell structure and functions of organelles.
- Immunology and Infection**:** acute and chronic inflammation, autoimmunity and autoimmune diseases, infections of musculoskeletal system (osteitis, osteomyelitis, enthesitis, synovitis, arthritis, etc), cardiac (endocarditis, myocarditis), gastrointestinal (gastritis, Crohn's & ulcerative colitis, hepatitis, cholecystitis), pyelonephritis, sialadenitis, vasculitis, etc.
- Vascular (Cell death and necrosis)**:** Cerebrovascular accidents, Myocardial infarction, pulmonary embolism, osteonecrosis, tumour necrosis, etc.
- Carcinogenesis: benign and malignant tumours, invasion, metastasis, cell proliferation, hypoxia, neo-angiogenesis, apoptosis, metabolism, and receptor expression

Pathophysiologic basis of Nuclear Medicine

Applied pathophysiologic concepts in Nuclear Medicine: Inflammation, Haematology, Musculoskeletal system, Endocrine system (Thyroid, Parathyroid, Adrenal glands), Digestive system, Genitourinary system, Respiratory system, Cardiovascular system, Central Nervous system, Oncology and Radionuclide therapy.

Applied Mathematics and Biostatistics

- General Mathematics: Powers, Exponents, Roots, Proportions, Logs, Using Linear & Semi Log papers, Differentiation and Integration

- Biostatistics: Percent error, Frequency tables, Measures of central tendency and dispersion, Probability distribution and its types, Error calculations, Coefficient of variance, Propagation of errors, tests of significant (Chi square test, t-tests), Correlation and Regression analysis.
- Applications in Nuclear Medicine: Count rate measurements, Error in measurements, Background correction, Calculation of activity decay and attenuation

Basic electronics

Fundamentals of electricity and electronics, power supply, electronic circuits (RC circuit, logic circuit, circuit breakers, and electronic switches), operational amplifiers, transistors. Analog to digital converter, Digital to Analog Converter.

Nuclear Physics

- Modes of Radioactive decay: Beta decay, Positron decay, Electron capture, Isomeric transition, Internal conversion, Alpha decay
- Radioactivity and decay of radioactivity: Half-life, Decay constant, Average lifetime, Decay factor, Image frame decay corrections, Specific activity, Apparent specific activity, Parent-daughter decay - Bateman equation and Types of equilibrium
- Radiation quantities and Units: Activity, KERMA, Exposure, Absorbed Dose, Equivalent dose, Effective dose, and Collective Effective Dose
- Interaction of radiation with matter: Charged particle interaction - Excitation and ionisation, Charged particles track, Linear energy deposition, Bremsstrahlung radiation, Cerenkov effect, Annihilation, Neutron capture and activation, Range of the charged particles; Photon interaction - Photoelectric effect, Compton scatter, Coherent scattering and Pair production
- Implications of interaction of radiation with matter: Scintillation - principle, classification, and application; Attenuation coefficient, HVL and TVL; Shielding calculations
- Introduction to radiation detection and radiation protection equipment: Scintillation, Semiconductor detectors.

Section B: General Biochemistry

- Carbohydrate chemistry: Monosaccharides, Disaccharides and Polysaccharides in health and disease
- Lipid chemistry: Simple, compound, and derived lipids, Lipoproteins in health and disease
- Protein chemistry: Amino acids, protein structure, protein denaturation
- Enzymes: Coenzymes, classification, Types of enzyme inhibition, Factors affecting enzyme activity; Clinical enzymology

- Nucleic acid chemistry: DNA, RNA
- Vitamins: Dietary sources, recommended dietary allowance, functions, and deficiency / toxicity of Vitamins
- Minerals: Dietary sources, recommended dietary allowance, functions, and deficiency / toxicity of Minerals
- Nutrition: basal metabolic rate, Protein Energy Malnutrition, Obesity, Food adulterants / additives
- Diabetes and Oral glucose tolerance test: Diagnosis and complications of diabetes,
- Renal and liver disease: RFT, LFT
- Myocardial infarction and Lipid profile: Cardiac markers

Practical:

Fundamental concepts in Nuclear Medicine

1. Identification of nuclear medicine equipment/instrument
2. pH determination using pH paper
3. Measuring weight using microbalance
4. Calculation of percent error, coefficient of variance, background correction, plotting of decay chart, attenuation, etc.

Biochemistry: No practical

Recommended Textbooks (latest edition):

Applied Pharmacology

1. Essentials of Medical Pharmacology, KD Tripathi, Jaypee Publishers

Applied Pathology

1. Robbins and Cotran Review of Pathology, Edward C Klatt and Vinay Kumar, Elsevier Saunders
2. Textbook of Pathology, Harsh Mohan, Jaypee Brothers Medical Publishers

Pathophysiologic Basis of Nuclear Medicine

1. The Pathophysiologic Basis of Nuclear Medicine, Abdelhamid H. Elgazzar, Springer publications

Applied Mathematics and Biostatistics

1. Practical Mathematics in Nuclear Medicine Technology. Patricia Wells, Society of Nuclear Medicine and Molecular Imaging

Nuclear Physics

1. Physics in Nuclear Medicine, Simon R Cherry, James A. Sorenson & Michael E. Phelps, Saunders Elsevier publications
2. Nuclear Radiation Detection, William J. Price, McGraw-Hill Book Company
3. Principles of Nuclear Medicine-Henry N. Wagner, W.B. Saunders company, London.
4. Principles and practice of Nuclear Medicine, Paul J. Early, D. Bruce Sodee, C.V. Mosby Company, Princeton

General Biochemistry

1. Medical laboratory Procedure Manual (T-M) by K.L. Mukerjee 1987, Vol.I, II & III Tata McGraw Hill Publication.
2. Textbook of Medical Biochemistry by Ramakrishna
3. Textbook of Clinical chemistry by Norbert Teitz.
4. Principles and Techniques of Practical Biochemistry by Wilson and Walker.
5. Clinical Chemistry - Principle and techniques by Rj Henry, Harper & Row Publishers.
6. Textbook Biochemistry by Vasudevan and Sree Kumari.

Phase II

Paper I: Instrumentation and Quality control of Nuclear Medicine equipment:

Theory:

Radiation detectors: Construction and Principles of Operation

- Gas Filled Detectors: Principles, construction, and functioning of Ionization Chamber, Isotope calibrator, Pocket dosimeter, Proportional Counter, Geiger Müller counter; Voltage calibration of a Geiger Müller tube, optimum operating condition and Dead time correction.

  Quality control of dose calibrator

- Scintillation detector:

  Thallium-activated Sodium Iodide crystal, Construction and functioning of Photo multiplier tube, high voltage supply, pre-amplifier, amplifier, Shielding, and collimation,

  Liquid scintillation detectors: composition of liquid scintillator (scintillation cocktail): primary solute, secondary solute and organic solvent (toluene, 1,4dioxane, anthracene) and solubilizing agents for tissues, Coincidence circuits and display.

- Semiconductor detectors: Principle, types, and properties of semiconductor detectors.

Spectrometer:

- Principles of Pulse-height analyser, single channel and multi-channel analysers, Calibration and Window settings, Determination of gamma energy spectrum, Integral and differential counting.
- Spectra of commonly used radionuclides e.g. I-131, Tc-99m, Cs-137, etc.
- Problems in radiation measurements with examples.
- Quality parameters of spectrometer - energy resolution, counting efficiency, energy linearity, integral counting, and differential counting

Nuclear Medicine Detector Equipment:

- Well counter:

  Construction and principles of operation, Crystal characteristics suited for detection of various radionuclides, Signal output, applications; Quality control of well counter

- Thyroid uptake probe & Intraoperative Probes: Types, Construction, basic working principles. Quality control of thyroid uptake probe and intraoperative probe
- Whole body counters: Construction, basic working principles and quality control
- Liquid scintillation counters: Construction, Quenching and quench corrections methods: Internal standard method, external standard method and channel ratio method.

- Neutron detectors: Basic principles and applications
- Gamma camera and SPECT/CT: Construction and principles of operation: Collimators and practical considerations - parallel hole and its types (based on quality parameters: high resolution, high sensitivity, general purpose; based on energy of incident ray: high/medium/low energy; slat hole), pin hole, diverging/converging, fan beam collimators.

  SPECT: Parameters of acquisition (linear sampling, angular sampling, degrees of rotation, continuous/step & shoot, circular/elliptical), 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.

  Quality control of gamma camera: Tuning, Uniformity, Linearity, Spatial resolution, Sensitivity, centre of rotation
- Positron Emission Tomography (PET) and PET/CT: Construction and working principles, PET crystals, acquisition protocols, 3D PET acquisition, time of flight, Hybrid PET/CT. Quality control of PET: Calibration with dose calibrator, Uniformity
- Computed Tomography: Construction and working principles, CT detectors, helical CT, acquisition protocols, CT reconstruction, CT based attenuation correction. Dose parameters. Quality control of CT

Other imaging and non-imaging equipment:

- Introduction to Ultrasound and MRI
- ECG monitor, Treadmill system, Infusion pump

Image physics: Types of images (planar - dynamic, static regional/whole body, gated, 3 dimensional), Intensity window settings and adjustment, Image filters, Interpolation, 3D image reconstruction (SPECT and PET) - Filtered Backprojection and Iterative methods, artefacts (scatter, motion, noise, attenuation, truncation, change in volume over time, gating)

Image Informatics: DICOM formats, Hospital Information System (HIS), and Picture Archival and Communication Systems (PACS).

Practical:

1. Calibration of spectrometer, finding energy resolution
2. Identification of an unknown radionuclide
3. Quality control of Dose Calibrator: Dose linearity, Constancy, Accuracy, Geometric variation
4. Quality control of gamma camera: Tuning, Uniformity, Linearity, Spatial resolution, Sensitivity, High count rate performance, Centre of rotation

5. Quality control of PET
6. Quality control of Computed Tomography
7. Thyroid uptake probe: Iso-response curve

Recommended Textbooks (latest edition):

Textbooks:

1. Physics in Nuclear Medicine, Simon R Cherry, James A. Sorenson & Michael E. Phelps, Saunders Elsevier publications
2. Essentials of Nuclear Medicine Physics and Instrumentation, Rachel A. Powsner, Matthew R. Palmer, Edward R. Powsner, Wiley Blackwell Publications
3. Basics of PET Imaging, Gopal B. Saha, Springer
4. Quality Control of Nuclear Medicine Instruments, International Atomic Energy Agency.

Reference books:

1. Nuclear Radiation Detection -William J. Price, McGraw-Hill Book Company
2. Principles of Nuclear Medicine-Henry N. Wagner, W.B. Saunders company, London
3. Principles and practice of Nuclear Medicine, Paul J. Early, D. Bruce Sodee. C.V. Mosby company Princeton
4. Quality Control of Gamma Cameras and Associated Computer Systems, The Institute of Physical Sciences in Medicine.
5. Quality Control of Nuclear Medicine Instrumentation, The Institute of Physical Sciences in Medicine.
6. Quality Control in diagnostic imaging, J.E. GRAY, University Park Press.
7. Processing and Quality Control, William, E.J. Mckinney.J.B. Lippincott Company.
8. Concepts in Medical Radiographic imaging, Marianne Tortoice, W.B. Saunders Company.
9. Quality assurance Management, G.E. Hayes Charger production.
10. Diagnostic Imaging: Quality Assurance M.M. Rehani. Jaypee Brothers Medical Publishers.

Paper II: Radiochemistry and Radiopharmacy

Theory:

Production of radionuclides:

- Nuclear reactor-produced radionuclides: Construction and functioning of nuclear reactor, nuclear fission reactions, fission products, Nuclear activation, and cross sections, Methods of radionuclide separation and purification, Characteristics of reactor-produced radionuclides
- Cyclotron-produced radionuclides: Construction and functioning of medical cyclotrons, types of cyclotrons, Methods of radionuclide separation and purification, Characteristics of cyclotron-produced radionuclides, Production of some commonly available radionuclides such as F-18, C-11, O-15, N-13, Tl-201, Ga-67, In-111, I-123

Radionuclide generators:

Parent - daughter relationships, Principles and construction of generator systems, Sterilization, Yield of a generator, commonly available generator systems such as Mo-99/Tc-99m, Ge-68/Ga-68, Sr-82/Rb-82, etc. Mo-99 and Aluminium breakthrough test

Radiopharmaceutical: Tracer concept, ideal characteristics of a radiopharmaceutical, factors influencing design of a radiopharmaceutical, Mechanism of localisation of radiopharmaceutical

Radiolabelling: Methods of radiolabelling, important factors in radiolabelling, Radiolabelling of cells and proteins

- Radioiodination: Methods and purification, commonly used radioiodinated compounds for diagnosis and therapy
- Labelling of radiopharmaceuticals chemistry of Tc-99m: Physical characteristics, Oxidation states, Chelation, ligand exchange reactions, Production of Cold kits for radiopharmaceutical preparation, Labelling of Tc-99m radiopharmaceuticals with cold kits such as DTPA, MIBI, DMSA, MDP, etc.
- Labelling of PET radiopharmaceuticals: Synthesis and purification of ^{18}F FDG, ^{68}Ga labelled radiopharmaceuticals, $^{13}NH_3$, etc.
- Labelling of therapeutic radiopharmaceuticals: Labelling chemistry of Lu-177, Re-188, etc.

Quality control of radiopharmaceuticals:

Physicochemical tests, Radionuclidic purity, Radiochemical purity, Sterilisation of radiopharmaceuticals, biological tests such as Sterility, Toxicity & Apyrogenicity testing

Dispensing of radiopharmaceuticals: Calculation of activity to be administered, routes of radiopharmaceutical administration, Specific activity

Tracer kinetic modelling: Basic concept of tracer kinetic modelling. Flow, Diffusion, Extraction, Kinetic modelling based on receptors, enzyme action, and metabolism.

Drug interactions with radiopharmaceuticals: Known interactions of drugs with radiopharmaceuticals and their effects.

Regulations, ethics, and registration of radiopharmaceuticals: Ethical use of radionuclides and radiopharmaceuticals in patient care and research. Regulatory authorities and procedures for registration of radiopharmaceuticals.

Practical:

1. Elution and calculation of yield of Molybdenum-99/Tc-99m generator
2. Preparation of Tc-99m labelled radiopharmaceuticals and dispensing of radiopharmaceuticals based on weight
3. Determination of ^{99}Mo breakthrough in ^{99m}Tc
4. Measurement of radiochemical purity by paper chromatography.

Recommended Textbooks (latest edition):

1. Fundamentals of Nuclear Pharmacy-Gopal B. Saha, Springer-Verlag, New York.
2. The handbook of Radiopharmaceutical -Mohan Patel & Samij Sadack, Chapman & Hall Medicals, London.
3. Nuclear Medicine Technology & Techniques-Donald R. Bernier, Paul E. Christian & James K. Langan Mosby.
4. Radiopharmaceuticals in Nuclear Pharmacy and Nuclear Medicine by Richard J. Kowalsky, American Pharmacists Association, USA

Paper III: Radiobiology & Radiation Protection

Theory:

Radiobiology

- General Cell Biology and mammalian cell growth and replication cycles, interaction of radiation with cells, mechanism of damage, nature of damage
- Effect of radiation on cells: Directly and indirectly ionising radiation, Direct and Indirect action of radiation, Deterministic (Tissue reaction) and Stochastic effects of radiation, Mechanisms of chromosomal & DNA damage and repair
- Cell survival curve, Linear-quadratic and multitarget models of cell damage, Mechanisms of cell killing, Relationship of dose, dose rate, oxygen, and cell age to radiosensitivity; Linear energy transfer and Relative Biological effectiveness of radiation
- Acute effects of radiation: Acute radiation syndrome, Prodromal, Cerebrovascular, Gastrointestinal, and Haematopoietic syndromes, Acute effects on lungs and skin; Medical countermeasures to radiation exposure (radioprotectors)
- Radiation cataractogenesis
- Radiation carcinogenesis: Mechanism of carcinogenesis and the role of radiation, Types of radiation-induced cancers and their temporal relation to the exposure, Cancer risk estimate to radiation, Dose and Dose-rate effectiveness factor (DDREF)
- Heritable effects of radiation: Mechanisms of radiation-induced heritable effects (Mendelian disorders, Chromosomal aberrations, and multifactorial disorders), Examples of such disorders in human beings.
- Effects of radiation on the embryo and foetus: Radiation-induced death and disorders and their relation to the radiation dose & gestational time
- Radiation risks in diagnostic and therapeutic Nuclear Medicine procedures: Effective whole body and organ doses to patients during Nuclear Medicine and relevant radiological diagnostic procedures; Occupational exposures to radiation workers.

Radiation protection

- Radiation protection: Principles of radiation protection, the need for radiation protection, Safe handling of radioactive materials, recommendations (ICRP, NCRP) and the regulatory requirements (IAEA, AERB), Negligible individual dose, Radiation detriment, ALARA, Dose limits to radiation workers, caregivers, and public, Annual limit of intake, Derived air concentration
- Radiation protective equipment: Shielding - lead barriers, syringe shields, lead aprons, lead gloves,

- Radiation monitoring devices: Personnel monitoring systems - pocket dosimeters, film badges and thermoluminescent dosimeters (chest, wrist, ring, eye, etc); Survey meters, Contamination monitors, zone monitors and phantoms
- Radiation monitoring procedures: Wipe test, Area monitoring and radiation survey of nuclear medicine lab
- Radioactive materials: Types of radioactive material packaging and testing; Transport of radioactive materials (Categories of radioactive materials and Transport Index), TREMCARD, Receipt of radioactive material - procedure and test for contamination, and maintenance of records
- Procedure for handling spills - Minor and major spills, Measures for containment, Decontamination procedure of Personnel, equipment and work area, decontamination kit
- Radiation emergencies and preparedness
- Radioactive waste management: Solid, Liquid, and Gaseous wastes; Principles of waste management, disposal of corpses containing therapeutic doses of radionuclides
- Misadministration: Definition, procedure for reporting, and measures to minimise such events

Practical:

1. Wipe test of nuclear medicine facility
2. Area monitoring and survey of nuclear medicine labs
3. Demonstration of management of radioactive spills and contamination

Recommended Textbooks (latest edition):

1. Radiobiology for the Radiologist. Eric J Hall, Amato J Giaccia, Wolters Kluwer
2. AERB Safety code for Nuclear Medicine
3. IAEA safety manuals

Phase III

Paper I: Diagnostic Nuclear Medicine Techniques

Theory:

Indications, Patient preparation, Study acquisition, Processing and Display of

- Renal system: Renogram, diuretic renogram, renogram to detect renovascular hypertension (ACE inhibitor, Angiotensin receptor antagonist, Aspirin and Exercise renograms), Vesicoureteric reflux study (Direct and Indirect), evaluation of donors and renal transplant recipients, and renal cortical imaging.
- Musculoskeletal system: Bone imaging - three phase, whole body and spot for various malignant and benign conditions (benign tumours, metabolic bone disease, trauma, vascular, infection and inflammation) F-18 Fluoride PET/CT, bone marrow imaging.
- Liver and Hepatobiliary system: Liver-spleen study, blood pool imaging, spleen imaging with denatured RBCs, Hepatobiliary imaging for function, bile leak, obstruction, neonatal cholestasis, biliary reflux, and Gall bladder functional evaluation.
- Gastrointestinal system: Salivary scintigraphy, Gastrointestinal motility studies (oesophageal transit, gastro-oesophageal reflux, gastric emptying, small & large bowel transit), Meckel's scan, and GI bleed study.
- Lung imaging system: Ventilation scan using Tc-99m DTPA aerosol, evaluation of aerosols generators, evaluation of COPD & Pulmonary permeability, lung perfusion imaging.
- Cardiovascular system: ERNA, First pass RNA, Stress-Rest myocardial perfusion imaging, myocardial viability studies (Tc-99m MIBI, Tl-201, F-18 FDG), cardiac inflammation imaging, sympathetic innervation imaging, and infarct imaging.
- Central nervous system: Brain perfusion/metabolism/Dopamine transporter imaging, Evaluation of epilepsy, cerebrovascular accident, dementia, motor neuron disorders, etc. CSF cisternography for CSF leak, patency of ventriculoperitoneal shunt, Evaluation of brain tumours (GHA, FDG, etc) and brain death.
- Endocrine system: Thyroid imaging and uptake (99mTc and 131I), 131I whole-body imaging, Parathyroid imaging, insulinoma, adrenal cortical and medullary imaging
- Oncology: lymphoma, cancers of breast/lung/gastrointestinal system/genitourinary tract, bone tumours, neuroendocrine tumours, brain tumours, etc. (such as F-18 FDG, F-18 Fluoride PET/CT, Ga-68 DOTANOC, I-131 MIBG)
- Miscellaneous: gastrointestinal protein loss estimation, Lymphoscintigraphy, Sentinel Lymph Node Imaging, Radioimmunoscintigraphy (RIS), Scrotal scintigraphy, pleuroperitoneal shunt, Hysterosalpingoscintigraphy, Scintimammography, Dacryoscintigraphy, Infection and inflammation imaging (Ga-67 citrate, Tc-99m labelled WBCs, F-18 FDG, F-18 FDG WBCs)

- Contrast-enhanced CT: types of contrast and precautions, multi-phasic CT
- Non-imaging procedures:

  In-vivo diagnostic procedures: Thyroid uptake study and Perchlorate discharge test

  In-vitro diagnostic studies: Radioimmunoassay (RIA) and Immunoradiometric assay (IRMA), Renal clearance measurements (GFR, ERPF), Urea breath analysis, Blood volume measurement, red blood cell life span, Intrinsic factor assay, Ferrokinetic studies
- Emergency nuclear medicine procedures.

Practical:

1. Patient preparation, Acquisition protocol, Data processing of planar, SPECT and SPECT/CT, and PET/CT images - musculoskeletal, cardiac, endocrine, hepatobiliary, gastrointestinal, genitourinary, infection, brain, and oncological imaging procedures
2. Patient preparation, performance, and display of results of non-imaging in-vivo and in-vitro nuclear medicine procedures

Recommended Textbooks (latest edition):

Textbooks:

1. Principles and Practice of Nuclear Medicine. Paul J. Early, D., Bruce Sodee

Reference books:

1. Mosbeys manual of Nuclear Medicine Procedures Bruce Sodee, Paul J.Early & Sharon Wikepry, Mosbey Company, London.
2. Essentials of Nuclear Medicine, M.V.Merrick
3. Basic Science of Nuclear Medicine, Roy P Parker, Peter A S Smith & David Churchill Livingston, New York 35
4. Essentials of Nuclear Medicine Imaging, Fred A Metter, Milton J
5. W B Saunders company, London Principles of Nuclear Medicine Henry N Wagner: W. B. Saunders company, London.
6. Clinical Nuclear Medicine M N Masey, K E Britton & D L Gilday Chapman and Hall medicals.
7. Nuclear Medicine Technology & Techniques - Donald R. Bernier, Paul E. Christian & James K. Langan Mosby.

Paper II: Therapeutic Nuclear Medicine Techniques and Radiation dosimetry

Theory:

- Ideal characteristics of therapeutic radionuclide. Choosing an appropriate radionuclide based on its physical characteristics and target requirements. Mechanism of cell killing.
- Radiation dosimetry: Basic concept of internal radiation dosimetry, MIRD method, Phantoms and software used for dosimetry, Quantitation of activity, Small scale dosimetry and microdosimetry, Dosimetry of various radionuclide therapies.
- Treatment of thyrotoxicosis: Indications, Patient preparation, dose calculations, administration of I-131 sodium iodide, post-treatment advice and follow up
- Treatment of differentiated thyroid cancers of follicular origin: Indications, pre-requisites, patient preparation, dose calculation, administration of I-131 sodium iodide, need for isolation, post-therapy scan, post-treatment advice and follow up
- mIBG therapy: Treatment of neuroblastoma and metastatic phaeochromocytoma/paraganglioma
- Peptide receptor radionuclide therapy: Indications (Neuroendocrine tumours, Prostate cancer), choice of radionuclide and ligand, pre-requisites, patient preparation, dose calculation, administration of radiopharmaceutical, need for isolation, post-therapy scan, post-treatment advice and follow up
- Bone pain palliation: Indications, choice of radiopharmaceutical, pre-requisites, patient preparation, post-therapy scan, post-treatment advice and follow up
- Radiation synovectomy: Indications, choice of radiopharmaceutical, pre-requisites, administration techniques, post-therapy scan, post-treatment advice and follow up
- Radioimmunotherapy: Merits of radioimmunotherapy, monoclonal antibodies, tumour antigens, biotin-avidin system pretargeting, cancers suitable for radioimmunotherapy, choice of radiopharmaceutical, pre-requisites, patient preparation, post-therapy scan, post-treatment advice and follow up
- Treatment of liver tumours with microspheres: Indications, choice of radiopharmaceutical, pre-requisites, patient preparation, post-therapy scan, post-treatment advice and follow up.
- Miscellaneous: Treatment of polycythaemia vera, malignant ascites, skin lesions including basal cell carcinoma

Practical:

1. Patient preparation, administration, and post-administration care in nuclear medicine treatment procedures - thyrotoxicosis, thyroid cancer, neuroendocrine tumour therapy and other internal radiation therapy procedures.

Recommended Textbooks (latest edition):

Textbooks:

1. Principles and practice of Nuclear Medicine, Bruce Sodee, Paul J.Early & Sharon Wikepry.

Reference books:

1. Basic Science of Nuclear Medicine, Roy P Parker, Peter A S Smith & David Churchill Livingston, New York 35.
2. Essentials of Nuclear Medicine, M. V. Merrick.
3. Mosbeys manual of Nuclear Medicine Procedures Bruce Sodee, Paul J.Early & Sharon Wikepry, Mosbey Company, London.
4. Essentials of Nuclear Medicine Imaging, Fred A Metter, Milton J
5. W B Saunders Company, London.
6. Principles of Nuclear Medicine Henry N Wagner:W B Saunders company, London.
7. Clinical Nuclear Medicine M N Masey, K E Britton & D L Gilday.
8. Chapman and Hall medicals.
9. Nuclear Medicine Technology & Techniques - Donald R. Bernier, Paul E. Christian, & James K. Langan Mosby.

Paper III: Recent advances, Planning and Regulatory Requirements

Theory:

Recent advances in Nuclear Medicine

- Recent advances in instrumentation: Digital PET systems, Total body PET/CT, PET/MRI, Breast-specific gamma cameras, Positron Emission Mammography, Cardiac-specific gamma cameras, small animal imaging systems, PET-guided biopsy
- Recent advances in image processing techniques: Introduction to newer reconstruction algorithms, partial-volume correction, and collimator-detector response recovery.
- PET: List mode, Dynamic PET, 4D imaging (Respiratory gating methods)
- Image-guided radiotherapy: Principles and applications
- Artificial intelligence in Nuclear imaging: Basic concept of artificial intelligence, Classification, and applications in nuclear imaging, processing, and analysis.
- Recent advances in radionuclide therapy: Theragnostics, Personalised Nuclear Medicine, Patient-specific dosimetry, Alpha therapy
- Recent advances in Radiopharmacy: Newer radiopharmaceuticals, Liposome-labelling, Nanotechnology, etc.

Planning and Regulatory Requirements

- Planning of Nuclear Medicine (NM) facilities: Classification and general features of NM laboratories (site, typical floor plan, ventilation, surface walls, floor and ceiling); Planning of radiation installation (Radiopharmacy, gamma camera, SPECT/CT, PET/CT, radionuclide therapy wards): protection from primary, leakage, and scattered radiation. Concepts of workload use factor, occupancy factor & distance.
- Barrier design: barrier materials-concrete, brick and lead, Primary & secondary barrier design calculations, design of doors, control of radiation-effects of time, distance and shielding.
- Regulatory requirements: AERB safety code and ethics, No Objection Certificates for facilities, radionuclides, and radiation equipment; Procedure for Commissioning, Operation, and Decommissioning of equipment, Calibration of radiation detection equipment (survey meters, area zone monitors, dose calibrators)
- Operational safety, Radiation protection programme, Personnel requirements and responsibilities, Annual report submission to AERB.
- Record keeping for radionuclide storage, waste disposal, survey, spills, misadministration, personnel dosimeter recordings, quality control of equipment
- Quality in Nuclear Medicine: Principles of quality, standards, measures to maintain quality

- Quality assurance of equipment: Acceptance test during installation - Routine daily check - checking the power line - Air conditioning efficiency - dust free atmosphere - Making the

availability of service then and there - Routine quality control study of different equipment periodically without delay. Maintenance of service record.

Practical:

1. Acquisition of dynamic PET, PET scan in list mode, and 4D PET scan
2. Demonstration of image fusion: PET and MRI, SPECT, and MRI
3. Preparation and discussion of a plan for a new nuclear medicine facility – SPECT, SPECT/CT, Low dose therapy, High dose therapy

Recommended Textbooks (latest edition):

Textbooks:

1. Radiation Protection in Hospitals. Richard F.Mould.

Reference books:

1. Basic radiological physics. Jaypee Brothers Private limited, New Delhi.
2. An Introduction to Radiation Protection. Allen Martin & Samuel.
3. Radiation safety in Medical practice. M.M. Rehani.
4. Radiation Protection. Ronald L. Kathren.
5. AERB safety code and manuals.

COURSE AND EXAMINATION REGULATIONS

Attendance:

- Students are required to attend 75% or more of all theory classes held, and 75% or more of practical in each subject to be eligible to appear in the final examination. Under no condition will a student with less than the prescribed attendance in any subject in theory and practical separately shall be allowed to appear in the Annual examination of that subject.
- Students with less than 75% attendance in theory and practical separately at the end of any year must start afresh by joining the junior batch of students. No extra classes will be arranged to make such students eligible for the final annual examinations. The attendance accrued in the previous academic year in those subject(s) will not be transferred. The student will need to secure 75% attendance afresh in theory and practical/laboratory postings after joining the junior batch to become eligible to appear in the final summative examination.
- The 25% leverage in attendance includes all types of leaves (including leave on medical grounds). For absence because of illness or any medical condition, a duly approved medical leave from Dean (Academic) with medical and fitness certificate issued/verified by authorized JIPMER clinical faculty member is mandatory. Certificate must be submitted before or within 10 days after availing medical leave.
- Students who are detained in all the subjects of a year due to lack of attendance should join the classes with junior batch within 7 days of declaration of the eligibility/detention list or when classes commence, whichever is earlier.
- Students who are detained in one or more subject(s) because of lack of attendance but are eligible to appear for final Annual examination in at least one subject of the year should join classes with junior batch within 7 days of completion of the last final theory/practical examination or when classes, whichever is earlier. Attendance will be calculated from the date of joining.
- A show cause notice will be issued to students on continuous unauthorized absence without prior permission for two weeks or more. If such absence extends to a period more than one month for any reason, the student is liable for termination for the course. The decision of the competent authority is final.
- There is **no condonation permissible** for shortage of attendance.

Internal Assessment (IA)

- A minimum of three notified internal assessments will be held periodically in each year (in a one-year period) and one model examination before the final annual examination.
- Each of the notified IA tests will carry 20% weightage and the model examination will carry 40% weightage. The sum of notified IA tests and model examination will decide the eligibility to appear in the examination and for contribution to aggregate marks.

- A student must secure at least 30% of the maximum marks fixed for internal assessment in theory and practical/clinical separately in a particular subject to be eligible to appear for the final annual examination in that subject.
- Of the final total aggregate marks in each subject, internal assessment marks will contribute 40% and annual examination marks will contribute the remaining 60%. This will apply to both theory and practical/clinical papers separately.
- If a student misses up to one notified test because of illness, marks of the remaining notified tests can be considered for calculating the internal assessment, ignoring the absence on medical grounds. To avail this concession, the student should submit a valid medical certificate signed by the treating clinical faculty member of JIPMER before or within 10 days after the missed test. This exemption will not apply to model examination. This is applicable only up to one missed notified internal assessment test.
- No repeat/additional notified internal assessment or model examination will be conducted.
- Students who are detained in all the subjects of a year because of lack of sufficient internal assessment marks should join the classes with junior batch within 7 days of declaration of the eligibility/detention list or when classes of the year commence, whichever is earlier.
- Students who are detained in one or more subject(s) due to lack of sufficient internal assessment marks but are eligible to appear in the annual examination in at least one subject of the year should join classes with junior batch within 7 days of completion of the last annual theory/practical examination or when classes of the year commence, whichever is earlier.
- The internal assessment marks accrued in the previous year will not be transferred to the next year.

Annual Examinations

Number and timing of examinations

- Annual examinations will be held at the end of each academic year. The Institute shall conduct not more than two annual examinations in an academic year, a regular annual and a supplementary examination in each subject. The supplementary examinations will be held within 6 weeks after publication of the result of the regular annual examination.
- Practical Examinations shall be jointly conducted by one internal and one external examiner duly appointed by the Professor of Examinations.
- Students should obtain a minimum of 40% in the annual examination and a minimum of 50% in the final total aggregate (total of internal assessment and annual examination marks) in a subject (theory and practical separately) to be declared as pass in that subject.

Marks scheme:

	Maximum marks
Theory	200
Practical	100
Total	**300**

Theory

	Maximum marks
Internal Assessment test 1	16
Internal Assessment test 2	16
Internal Assessment test 3	16
Model Examination	32
Annual Theory Examination	100
Viva-voce Examination	20
Total Theory marks	**200**

Practical

	Maximum marks
Internal Assessment test 1	7
Internal Assessment test 2	7
Internal Assessment test 3	7
Model Examination	14
Record marks	5
Annual Practical Examination	60
Total Practical marks	**100**

Question paper pattern

	Maximum marks
Section A	50
Section B	50
Total	**100**

Each section

		Marks
Answer in detail	1 X 10	10
Short notes	5 X 5	25
Brief answers	5 X 3	15
		50

Number of attempts and Training Period

- The academic program of the BSc Allied Health Sciences courses must be completed within 6 years from the date of joining (excluding internship). Maximum permissible duration for each year shall be four years and a maximum four attempts (including the annual and supplementary examinations) in any subject will be permitted.
- If a student does not appear in both theory and practical final examination, it will NOT be considered as an attempt for the purpose of calculation of maximum number of attempts in a subject.
- If a student appears for theory in the Annual Examination but does not appear for Practical Examination or vice-versa, his/her theory or practical appearance shall be counted as an attempt. In the next attempt, the student will have to appear for both Theory and Practical Examinations. Mere submission of application form for examination will not be considered as an attempt.
- Passing in the exams of all the previous year subjects is compulsory before proceeding to the classes of next phase.
- A student who fails in theory and/or practical papers of one or more subjects in the regular annual examinations at the end of each year can appear in the supplementary examination (to be held within 6 weeks of announcement of the regular annual examination results) in those subjects.
- If he/she passes these subjects in the supplementary examination, he/she should join the regular batch within 7 days of declaration of supplementary examination results or when classes commence, whichever is earlier. Attendance calculation for students who join after passing supplementary examination will begin from their date of joining of that year.
- Students who fail in theory and/or practical in one or more subjects in the supplementary examination and those who do not appear in the supplementary examination should join classes with the junior batch within 7 days of declaration of supplementary examination results or when classes, whichever is earlier. These students should secure 75% attendance and 30% internal assessment afresh to be eligible to appear in the final regular annual examination of that year along with the junior batch. Attendance calculation for students who join after failing in supplementary examination will begin from their date of joining the year with junior batch.
- A maximum of four attempts in any subject is allowed. If a student fails even in the 4^{th} attempt, no further chances will be given, and his/her name will be struck off the rolls of JIPMER.
- No grace marks will be awarded for either theory or practical examinations under any circumstances.

Model Question paper

Phase I - Paper I: Foundation course

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Describe in detail healthcare delivery system in India at the primary, secondary, and tertiary levels.

2. Write short notes on the following: 5 x 5 = 25

a. What is the role of processor and RAM in a computer?
b. Describe the types of networks in computing.
c. Write a short note on right to healthcare.
d. What is medical negligence? What are the laws governing medical negligence in India?
e. Write in brief about the importance of informed consent and the process.

3. Answer the following questions briefly: 5 x 3 = 15

a. What are the components of a medical term?
b. What are the input and output devices of a computer?
c. What is paralanguage? What are its implications?
d. Describe the characteristics of good communicator.
e. What are the alternative medicine systems recognised by the Government of India?

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. Explain the concepts of quality of care. Describe various approaches to quality improvement.

2. Write short notes on the following: 5 x 5 = 25

a. Describe the principles of management with suitable examples.
b. Describe the methods of disinfection in biomedical waste management.
c. Describe the methods of prevention & control of common healthcare associated infections.
d. Classify the types of antibiotic resistance and describe each of them.
e. Write a short note on research study designs.

3. Answer the following questions briefly: 5 x 3 = 15

a. What are the components of cardiopulmonary resuscitation?
b. What is integrity and what is its importance of integrity in healthcare practice?
c. What are the qualities of a good leader?
d. What are the different types of data?
e. Describe the concept of ethics and its relevance in healthcare practice.

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Model Question paper

Phase I - Paper II: Anatomy and Physiology

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary

Section A - Anatomy

1. Answer the following question in detail: 1 x 10 = 10

a. Describe the position, parts, structure, blood supply and supports of uterus.

2. Write short notes on the following: 5 x 5 = 25

a. Parts and blood supply of stomach
b. Simple epithelium
c. Histology of lymph node
d. Chambers and valves of heart
e. Surfaces and lobes of lung

3. Answer the following questions briefly: 5 x 3 = 15

a. Name three major salivary glands.
b. Mention two contents of spermatic cord
c. Name two paranasal air sinuses
d. Name the parts of small intestine
e. Name two upper limb muscles

Section – B - Physiology

1. Write essay answer on the following: 1 x 10 = 10

a. Define immunity. Mention the different types of immunity. Write briefly about the different types of immunity. (2+2+6)

2. Write short notes on the following: 5 x 5 = 25

a. Active transport
b. Movements of small intestine
c. Factors affecting glomerular filtration rate
d. Oxygen haemoglobin (Oxy-Hb) dissociation curve
e. Factors regulating cardiac output

3. Write very short answers on the following: 5 x 3 = 15

a. Name the hormones secreted from Adrenal gland
b. Mention the Indicators of ovulation
c. Define tidal volume. Mention its normal value.
d. Draw a labelled diagram of lead II ECG.
e. List four functions of hypothalamus.

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Model Question paper

Phase I - Paper III: Pathology and Microbiology

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary

Section A - Pathology

1. Answer the following question in detail: 1 x 10 = 10

a. What is inflammation? What are the cardinal signs of inflammation? Mention the difference between acute and chronic inflammation. Add a note on granuloma with example. (1+2+4+3)

2. Write short notes on the following: 5 x 5 = 25

a. Define necrosis (1). Give examples of different types of necrosis (2). Differences between necrosis and apoptosis (2).
b. What is thrombosis (1)? Explain Virchow's triad (4).
c. Define neoplasia (1). What are the differences between benign and malignant tumours (2)? List the different routes of metastasis (2).
d. Mention the differences between wound healing by primary and secondary intention (5).
e. Principles and procedures of blood grouping (3) and cross-matching (2).

3. Answer the following questions briefly: 5 x 3 = 15

a. Define anemia. Give any two causes of anemia.
b. What is jaundice? Give the classification based on pathophysiology.
c. What is atherosclerosis? Give some of its risk factors.
d. What is nephrotic syndrome? Give any two examples.
e. How will you do urine analysis?

Section – B - Microbiology

1. Write essay answer on the following: 1 x 10 = 10

a. Define sterilization. Draw a labelled diagram of autoclave. Write principle of autoclave and its application in hospital. (1+3+3+3)

2. Write short notes on the following: 5 x 5 = 25

a. Enumerate vector borne diseases. Add a note on the laboratory diagnosis of malaria
b. What do you understand by segregation of biomedical waste? How is it done in your hospital?
c. Describe in detail about various method of urine sample collection
d. Enumerate sexually transmitted microorganisms. Write laboratory diagnosis of HIV
e. Describe laboratory diagnosis of Mucormycosis.

3. Write very short answers on the following: 5 x 3 = 15

a. Name two transport media
b. Name two foodborne pathogens
c. Enumerate four Personal Protective Equipment (PPE)
d. Name two nosocomial pathogens
e. List two opportunistic fungal infection

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Model Question paper

Phase I - Paper IV: Preparatory concepts in Nuclear Medicine

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Explain in detail photoelectric effect and Compton scatter with suitable diagrams. Discuss the implications of these interactions in imaging photons.

2. Write short notes on the following: 5 x 5 = 25

a. Define half value layer. If 2 mm of a material absorbs 20% of incident rays of 140 keV energy, what is the half value layer of the material? (Natural log of 1.25 ~ 0.22)
b. Describe iodine metabolism in human beings with emphasis on thyroid.
c. Describe positron annihilation process with suitable diagram. What is the primary difference in principle of imaging positron emitters and gamma emitters?
d. A sample of 50 mCi of Tc-99m pertechnetate in 5 ml was available 8 AM on a day. If 10 mCi of Tc-99m pertechnetate is required at 10 AM on the same day, what volume of the original sample should be obtained?
e. Calculate mean, median, mode, variance, standard deviation, and coefficient of variance of the following counts obtained from repeated measures of a sample of long-lived radionuclide.
3456, 3564, 3349, 3428, 3507, 3469, 3466, 3490

3. Answer the following questions briefly: 5 x 3 = 15

a. What is the mechanism of action of loop diuretics? Give two examples.
b. Mention the classical signs of inflammation with the reason for their development.
c. What is epilepsy? What are the common causes? In which type of epilepsy does nuclear imaging have a role?
d. Mention any four risk factors ischaemic heart disease. What is angina pectoris?
e. Describe in brief the steps of cell apoptosis.

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. Describe the concept of tracer. List and briefly describe various mechanisms of localisation of radiopharmaceuticals.

2. Write short notes on the following: 5 x 5 = 25

a. Explain the working principle of gel filtration chromatography.
b. Mention the biochemical tests for assessment of iron status and briefly describe them.
c. Describe the mechanisms of action of enzymes.
d. Describe the biochemical functions of Vitamin K.
e. What is basal metabolic rate and what is its significance?

3. Answer the following questions briefly: 5 x 3 = 15

a. How is 1M of NaCl prepared?
b. What is Bohr effect?
c. Name and briefly describe a test to detect protein in urine.
d. Name any two richest sources of vitamin C and describe its role in the human body.
e. Describe various types of pipettes and their applications.

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Model Question paper

Phase II - Paper I: Nuclear Medicine Instrumentation and Quality control

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Describe with an illustration the effect of voltage on output current in a gas detector that is exposed to ionising radiation. Explain the application of gas detectors in nuclear medicine with suitable examples.

2. Write short notes on the following: 5 x 5 = 25

a. Explain the process of scintillation and its significance in nuclear medicine.
b. Describe the construction and functioning of a block detector in a PET scanner with a suitable diagram.
c. Define energy resolution of a gamma camera. List and discuss the factors that influence energy resolution of a gamma camera.
d. Describe the function of a pulse height analyser with suitable diagrams. What is its role in nuclear medicine equipment?
e. What is the need for collimation in a gamma camera? List various types of collimators and their characteristics and applications.

3. Answer the following questions briefly: 5 x 3 = 15

a. Explain why LSO crystal is used as a detector instead of sodium iodide in PET scanners.
b. Explain how the measure of standardised uptake value (SUV) is obtained.
c. What is non-colinearity in PET detection? What is its effect on image?
d. What are the advantages of incorporating CT in a gamma camera system (SPECT/CT)?
e. Draw a schematic diagram of an intraoperative gamma probe.

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. What are the factors that affect spatial resolution of PET images? Describe the mechanisms to improve spatial resolution. (5 + 5 marks)

2. Write short notes on the following: 5 x 5 = 25

a. What are the factors that lead to non-uniformity of gamma camera? How is uniformity correction performed?
b. Define detection efficiency of a scintillation detector. Explain the factors that affect efficiency.
c. List SPECT artefacts and describe one of them in detail.
d. Write a short note on iterative reconstruction of images. What are the advantages?
e. What is normalisation in PET? How is it accomplished?

3. Answer the following questions briefly: 5 x 3 = 15

a. What is isoresponse curve of a thyroid uptake probe?
b. What are the effects of non-linearity of a gamma camera?
c. Describe in brief DICOM file formats.
d. Compare the performance of scintillation and semiconductor detectors.
e. What is point-spread-function?

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Model Question paper

Phase II - Paper II: Radiochemistry and Radiopharmacy

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Describe the chemical characteristics of Technetium-99m that make it a suitable radiolabel in gamma imaging. What are the different oxidation states of Tc-99m? Describe the mechanisms of chelation and transchelation with suitable examples. (4+2+4)

2. Write short notes on the following: 5 x 5 = 25

a. Enlist any four reactor-produced radionuclides. Describe the characteristics of reactor-produced radionuclides. (2+3)
b. What is autoclaving? What is its role in radiopharmaceutical preparation? (3+2)
c. What is apyrogenecity of a radiopharmaceutical? How is it tested? (1+4)
d. Describe the principle of solvent-extraction Mo-99/Tc-99m generator. What are its advantages and limitations? (2+3)
e. Enlist various methods of radioiodination. Describe any one method briefly. (2+3)

3. Answer the following questions briefly: 5 x 3 = 15

a. What is isotope exchange reaction? Explain examples.
b. Name two radiolabelled antibodies for imaging.
c. Mention the advantages of I-123 mIBG over I-131 mIBG in imaging.
d. Why is pH of a prepared radiopharmacuetical important? How is pH adjusted during radiopharmaceutical preparation?
e. Define radionuclidic purity of radionuclides. How is it tested?

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. Describe in detail the different methods of radiolabelling of red blood cells with Tc-99m.

2. Write short notes on the following: 5 x 5 = 25

a. Write in detail about the construction and elution methods of Ge-68/Ga-68 generator.
b. Describe the production of F-18.
c. What is the principle behind the use of somatostatin receptor analogues in imaging? Explain with suitable examples.
d. Describe the construction of a cyclotron in brief with a suitable diagram.
e. Describe the construction of the $^{188}W/^{188}Re$ generator. What are the applications of ^{188}Re?

3. Answer the following questions briefly: 5 x 3 = 15

a. Mention six radiopharmaceuticals labelled with ^{11}C.
b. How is radiochemical purity of F-18 FDG done?
c. Write down Bateman's equation of radionuclide generators. What is the application of it?
d. How is concentration of Tc-99m in the eluate maintained through a week?
e. Define specific activity of a radionuclide. What is its practical implication?

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Model Question paper

Phase II – Paper III: Radiobiology & Radiation Protection

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. What is acute radiation syndrome? Describe the clinical features in each of the phases and the radiation dose level associated with it.

2. Write short notes on the following: 5 x 5 = 25

a. What is the influence of oxygen on radiation-induced damage to DNA? What are its clinical implications?
b. Write a short on radiation-induced cataract formation.
c. Explain the rationale behind dose fractionation in radiation therapy.
d. A radiation worker is accidentally exposed to an internal dose of 100 mCi of I-131. Discuss the possible effects of radiation on the worker.
e. What are the characteristics of stochastic effects of radiation? Explain with suitable examples.

3. Answer the following questions briefly: 5 x 3 = 15

a. Define radiation and tissue weighting factors.
b. What is comet assay? What is the application?
c. Define plating efficiency. What is the application?
d. Define dose and dose-rate effectiveness factor (DDREF). What are its implications?
e. What is a second malignancy? Give few examples.

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. Describe different cell survival curve-based models to depict the effect of radiation on cells.

2. Write short notes on the following: 5 x 5 = 25

a. Describe radiation package tests.
b. What is transport index? Explain how it is calculated. Describe in brief the information provided on radiation packages being transported.
c. Describe the procedure of radiation decontamination procedure in a radiation spill situation.
d. Describe the construction of a thermoluminescent dosimeter (TLD). How is the information obtained from a TLD?
e. What is misadministration? Discuss a few methods to prevent misadministration.

3. Answer the following questions briefly: 5 x 3 = 15

a. What is radiation hormesis? What are the implications?
b. Write in brief about ALARA.
c. Define deterministic effect of radiation. Give examples of deterministic effects that may be encountered in Nuclear Medicine.
d. What are radiation sensitisers? Explain with examples.
e. What are the permissible annual exposure limits to radiation workers as per AERB safety code?

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Model Question paper

Phase III - Paper I: Diagnostic Nuclear Medicine Techniques

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Describe the radiopharmaceuticals used, patient preparation, and procedure of stress myocardial perfusion scintigraphy.

2. Write short notes on the following: 5 x 5 = 25

a. A patient with diabetic foot ulcer is being evaluated for suspected underlying osteomyelitis. Describe the scan procedure to rule out osteomyelitis in this patient.
b. A 15-days old child presents with neonatal cholestasis. Mention the nuclear medicine study appropriate for the management of this child and briefly describe the study procedure.
c. A 1-year old child has recurrent vomiting and history of recurrent pneumonia. Mention the nuclear medicine study appropriate for the management of this child and briefly describe the study procedure.
d. A 65-year old man suffers from backache for the past 4 months. His serum PSA level is 250 ng/ml. Mention the relevant nuclear medicine study indicated for this patient and briefly describe the study procedure.
e. A 6-month old child has hydronephrosis of left kidney and the dilatation of pelvicalyceal system is increasing in size. Which is the appropriate study? Describe the study procedure.

3. Answer the following questions briefly: 5 x 3 = 15

a. What are the advantages of F-15 protocol over F0 protocol?
b. List various radiopharmaceuticals for lung ventilation imaging and mention their merits and limitations.
c. Mention the radiopharmaceutical and briefly describe the study procedure of scrotal scintigraphy.
d. Mention the quantitative parameters of oesophageal scintigraphy.
e. Explain the principle of dual-point imaging in PET and mention its applications.

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. A 50-year old man with type 2 diabetes and poor glycaemic control has gastric carcinoma and is referred for FDG PET/CT for the evaluation of distant metastasis. Describe patient preparation and study procedure.

2. Write short notes on the following: 5 x 5 = 25

a. Explain the principle and describe the study procedure of ictal and interictal SPECT.
b. Explain the principle and describe subtraction parathyroid scintigraphy.
c. Describe the study procedure of thyroid uptake study and mention the normal range of values.
d. A 40-year old woman complains of bloating of abdomen after meals. Mention the appropriate study and describe the procedure in brief.
e. Write a short note on myocardial viability imaging.

3. Answer the following questions briefly: 5 x 3 = 15

a. Explain the principle of denatured red blood cell scan.
b. Briefly describe the study procedure of dacryoscintigraphy.
c. Explain the principle of sentinel lymph node imaging and mention the radiopharmaceuticals used for it.
d. Explain forward and reverse gating techniques?
e. Briefly describe the study procedure of salivary scintigraphy.

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Model Question paper

Phase III - Paper II: Therapeutic Nuclear Medicine Techniques and Radiation dosimetry

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. Describe patient preparation, administered dose, administration procedure, and post-administration procedure of high dose radioiodine treatment for thyroid cancer after a total thyroidectomy.

2. Write short notes on the following: 5 x 5 = 25

a. Describe patient selection, preparation, and administration of peptide receptor radionuclide therapy for neuroblastoma.
b. Discuss the characteristics of I-131 that make it suitable for treatment of thyroid diseases.
c. Describe the mechanism of localisation and patient preparation for I-131 MIBG therapy.
d. List various radionuclides/radiopharmaceuticals available for bone pain palliation and discuss their merits and limitations.
e. List indications, radiopharmaceuticals, mechanism of action of transarterial embolization of hepatic tumours. Describe the administration procedure in brief.

3. Answer the following questions briefly: 5 x 3 = 15

a. What is S factor?
b. Describe briefly an MIRD phantom.
c. List somatostatin receptor analogues for imaging and mention merits of each of them.
d. What is a critical organ? How is it determined?
e. How can basal cell carcinoma be treated with radionuclides?

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. List radiopharmaceuticals available for radiosynovectomy and discuss their merits and limitations. Describe the procedure and post-procedure care.

2. Write short notes on the following: 5 x 5 = 25

a. What are the prerequisites for bone pain palliation treatment? List the post-procedure advice given to the patients.
b. Write a short note on the indications and procedure of Lu-177 PSMA therapy.
c. Discuss the ideal characteristics of a therapeutic radionuclide.
d. Describe patient selection, preparation, and dose calculation for radioiodine treatment of thyrotoxicosis.
e. Write a short note on radioimmunotherapy of lymphoma.

3. Answer the following questions briefly: 5 x 3 = 15

a. Write in brief how malignant ascites can be treated with internal radiation.
b. What is Bremsstrahlung imaging?
c. What is the purpose of post-therapy scans?
d. A patient with thyroid cancer has recently undergone a contrast-CT and requires radioiodine treatment. What is the strategy?
e. A lactating mother requires radioiodine treatment for thyroid cancer. Explain the strategy.

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Model Question paper

Phase III - Paper III: Recent advances, Planning and Regulatory Requirements

Maximum marks: 100 Maximum duration: 3 hours

Answer all the questions. Draw suitable diagrams where necessary.

Section A

1. Answer the following question in detail: 1 x 10 = 10

a. What are the characteristics of cardiac-specific gamma cameras? What are the advantages over a conventional gamma camera? Describe the construction of the available systems and discuss the suitability of such equipment in a nuclear medicine department.

2. Write short notes on the following: 5 x 5 = 25

a. Write a short note on the newer developments in intraoperative probes.
b. What is the 4D PET? Describe various instruments involved in acquiring 4D PET.
c. Write a short note on total lesion glycolysis and its applications.
d. Explain the concept of collimator-detector response recovery and mention its applications.
e. Discuss the indications and merits of using list mode acquisition in PET?

3. Answer the following questions briefly: 5 x 3 = 15

a. Name any three alpha-emitters and mention their applications.
b. Explain personalised medicine with a suitable example.
c. Briefly explain the concept of machine learning with a relevant example.
d. What is FAPI and what is its application?
e. Mention the advantage of CT-based attenuation correction over previously described methods.

Section B

1. Answer the following question in detail: 1 x 10 = 10

a. List alpha-emitters for treatment and discuss the advantages and limitations with suitable examples.

2. Write short notes on the following: 5 x 5 = 25

a. Explain the concept of theragnostics with suitable examples.
b. Depict the plan for a nuclear medicine facility with PET/CT and low dose radionuclide therapy with the help of a schematic diagram.
c. Define quality assurance. Describe the quality assurance tests done at the time of installation of a SPECT/CT.
d. Describe the barrier design for a radioiodine therapy ward.
e. What design characteristics are essential in a diagnostic Radiopharmacy?

3. Answer the following questions briefly: 5 x 3 = 15

a. Name the methods of MRI-based attenuation correction of PET images.
b. What are the recommended methods of disposal of solid radioactive waste?
c. List the roles of a nuclear medicine technologist in a nuclear medicine facility.
d. What are the essential roles of the International Commission on Radiological Protection with reference to nuclear medicine?
e. Briefly describe the procedure of radioactive source procurement as per AERB regulations.

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