



MANIPAL
ACADEMY of HIGHER EDUCATION
(Institution of Eminence Deemed to be University)

Manipal College of Health Professions

Manipal Academy of Higher Education, Manipal

Outcome-Based Education (OBE) Framework

**Four Years Full Time
Undergraduate Program
(Choice-Based Credit System)**

**Bachelor of Science in
Nuclear Medicine Technology
(B.Sc. NMT)**

With effect from July 2024

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Head of the Department

Dean

Deputy Registrar - Academics

Registrar

1. Nature and extent of the program

The department of Nuclear Medicine has been in existence in Kasturba Hospital since 1985. Initially it was under the department of Radiotherapy. From 1992 a two year DNMT program was offered, since 1993 Bachelor's program was offered which was upgraded to four years dual degree program from 2001. Master of Science in Nuclear Medicine Technology (MSc NMT) was started in 2008. Since 1999 with the inception of the College of Allied Health Sciences, Nuclear Medicine became an integral part of it.

The B.Sc. NMT, Program is under Manipal College of Health Professions (MCHP) and is a 4 year full time course affiliated to Manipal University

The academic program is designed in such a way to meet the challenges in management in a health care organization through organized training sessions in the department as well as in various associated hospitals.

Candidates with this degree can pursue their career as Nuclear Medicine Technologists in the Nuclear Medicine Departments of any hospital in any Asian Country. Candidates can also pursue their higher education in the same discipline.

Professional Agenda

- Ensure high standard and discipline of the profession.
- Develop and maintain the technical profession in Nuclear Medicine.
- Widening the knowledge of practice, skills and research work.
- Impart academic knowledge and advances in professional practice.

Duration

The B.Sc. NMT, Program is under Manipal College of Health Professions (MCHP) and is a 4 year (3 years course work + 1 year internship) full time course affiliated to Manipal Academy of Higher Education.

To enable students to achieve the personal, professional and academic development required to become competent Nuclear Medicine Technology professional with the ability to meet the needs of changing context of Nuclear Medicine field.

Successful completion of the program will enable the student to be awarded a Bachelor of Science in Nuclear Medicine Technology (B.Sc.NMT)

Professional Aims

By the end of the program students should be able to:

- Acquire knowledge of practice relevant to Nuclear Medicine Technology.
- Use formal research as a tool to evaluate and develop practice.
- Identify his/her professional learning and developmental needs.
- Work collaboratively with other health care professionals to achieve a quality service.
- Enable health care organization for better management of patients.
- Uphold legal ethical standards within his/ her profession.

Eligibility Criteria

- a) The candidate must have passed 10+2/A level International Board/ American 12th grade of equivalent from Science group (Physics and Chemistry are compulsory subjects with a third subject as either Biology or Mathematics).
- b) Candidate must have obtained minimum of 50% marks in aggregate or equivalent grade points in respective qualifying exams.
- c) Lateral entry is not permitted.

Age at Entry

By 31st December of the year of admission, the candidate must complete a minimum age of
17 years

Scope

Candidates with this degree can pursue their career as Nuclear Medicine Physicists/Technologist/Research Assistant/ Managers/Application Specialist in the Service, Academics, Research & Development sectors of Nuclear Medicine.

2. PROGRAM EDUCATION OBJECTIVES (PEOS)

The overall objective of the learning outcome-based curriculum framework (LOCF) for B.Sc. NMT Program are as follows:

PEO No.	Education Objective
PEO 1	Students will be able to use their fundamental knowledge and clinical competence in Nuclear Medicine Science and Technology as and when required to achieve professional excellence.
PEO 2	Students will demonstrate strong and well defined clinical and practical skills in Nuclear medicine diagnostic and therapeutic procedures, radiation safety, Nuclear medicine instrumentation, Radiochemistry and Radiopharmacy
PEO 3	Students will be able to practice the profession with highly professional and ethical attitude, strong communication skills, and effective professional skills to work in a inter-disciplinary team.
PEO 4	Students will be able to use interpersonal and collaborative skills to identify, assess and formulate problems and execute the solution.
PEO 5	Students will be able to imbibe the culture of research, innovation, entrepreneurship and incubation.
PEO 6	Students will be able to participate in lifelong learning process for a highly productive career and will be able to relate the concepts of Medicine, Biology, Radiobiology, Nuclear Physics and Radiochemistry towards serving the cause of the society.

3. GRADUATE ATTRIBUTES

S No.	Attribute	Description
1	Professional Knowledge	Demonstrate scientific knowledge and understanding to work as a health care professional
2	Clinical / technical / Laboratory / practical skills	Demonstrate Clinical, technical and practical skills in order to implement the preventive, assessment and management plans for quality health care services
3.	Communication	Ability to communicate effectively and appropriately in writing and orally to patients/clients, care-givers, other health professionals and other members of the community
4.	Cooperation/Team work	Ability to work effectively and respectfully with interdisciplinary team members to achieve coordinated, high quality health care
5.	Professional ethics	Ability to identify ethical issues and apply the ethical values in the professional life
6.	Research / Innovation-related Skills	A sense of inquiry and investigation for raising relevant and contemporary questions, synthesizing and articulating.
7.	Critical thinking and problem solving	Ability to think critically and apply once learning to real-life situations
8.	Reflective thinking	Ability to employ reflective thinking along with the ability to create the sense of awareness of one self and society
9.	Information/digital literacy	Ability to use ICT in a variety of learning situations
10.	Multi-cultural competence	Ability to effectively engage in a multicultural society and interact respectfully
11.	Leadership readiness/qualities	Ability to respond in an autonomous and confident manner to planned and uncertain situations, and should be able to manage themselves and others effectively
12.	Lifelong Learning	Every graduate to be converted into lifelong learner and consistently update himself or herself with current knowledge, skills and technologies. Acquiring Knowledge and creating the understanding in learners that learning will continue throughout life.

4. QUALIFICATION DESCRIPTORS:

- a) Demonstrate (i) a fundamental and systematic knowledge and understanding of an academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues in the field of Nuclear Medicine Science and Technology; (ii) Procedural knowledge that creates different types of professionals related to the Nuclear Medicine Science and Technology, including research and development, teaching and in government and public service; (iii) Professional and communication skills in the domain of Nuclear Medicine Science and Technology, including a critical understanding of the latest developments, and an ability to use established techniques in the domain of Nuclear Medicine Science and Technology.
- b) Demonstrate comprehensive knowledge about Nuclear Medicine Science and Technology, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to the Nuclear Medicine Science and Technology, and techniques and skills required for identifying problems and issues.
- c) Demonstrate skills in i) identifying the issues in Nuclear Medicine Science and Technology; ii) collection of quantitative and/or qualitative data relevant to client's needs and professional practice; iii) analysis and interpretation of data using methodologies as appropriate for formulating evidence based hypotheses and solutions
- d) Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the Nuclear Medicine Science and Technology
- e) Communicate appropriately with all stakeholders, and provide relevant information to the members of the healthcare team
- f) Address one's own learning needs relating to current and emerging areas of study, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge
- g) Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems

5. PROGRAM OUTCOMES (POs):

After successful completion of B.Sc.Nuclear Medicine Technology (B.Sc.NMT) program, students will be able to:

PO No.	Attribute	Competency
PO 1	Professional knowledge	Possess and acquire scientific knowledge to work as a health care professional
PO 2	Clinical/ Technical skills	Demonstrate and possess clinical skills to provide quality health care services
PO 3	Team work	Demonstrate team work skills to support shared goals with the interdisciplinary health care team to improve societal health
PO 4	Ethical value & professionalism	Possess and demonstrate ethical values and professionalism within the legal framework of the society
PO 5	Communication	Communicate effectively and appropriately with the interdisciplinary health care team and the society
PO 6	Evidence based practice	Demonstrate high quality evidence based practice that leads to excellence in professional practice
PO 7	Life-long learning	Enhance knowledge and skills with the use of advancing technology for the continual improvement of professional practice
PO 8	Entrepreneurship, leadership and mentorship	Display entrepreneurship, leadership and mentorship skills to practice independently as well as in collaboration with the interdisciplinary health care team

6. COURSE STRUCTURE, COURSE WISE LEARNING OBJECTIVE, COURSE OUTCOMES (COs)

SEMESTER I

Course Code	Course title	Credit distribution (L,T,P, CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
ANA1303	Anatomy	3	-	-	-	3	30	70	100
PHY1301	Physiology-I	2	-	-	-	2	30	70	100
NMT1301	Fundamentals of Electronics	2	1	-	-	3	50	50	100
NMT1302	Radiation Physics	3	1	-	-	4	50	50	100
NMT1303	Practicum –I	-	1	6	-	4	50	50	100
NMT1304	Lab Practice	-	1	6	-	4	100	-	100
	Total	10	4	12	-	20	310	290	600

Note: ESE for

- ANA1303 & PHY1301 will be conducted for 50 marks and normalized to 70 marks for grading.
- NMT1301, NMT1302 and NMT1303 will be conducted for 100 marks and scaled to 50 marks for grading.

SEMESTER II

Course Code	Course title	Credit distribution (L,T,P, CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
PHY1401	Physiology - II	2	-	-	-	2	30	70	100
BIC1401	Biochemistry	3	-	-	-	3	30	70	100
EIC1501	Environmental Science and Indian Constitution	2	-	-	-	2	100	-	100
CSK1501	Communication Skill	2	-	-	-	2	100	-	100
NMT1401	Cell and Molecular Biology	3	1	-	-	4	50	50	100
NMT1402	Bioethics and Patient Care	2	1	-	-	3	50	50	100
NMT1403	Practicum - II	-	1	4	-	3	50	50	100
NMT1404	Clinical Practice	-	-	-	3	1	100	-	100
	Total	14	3	4	3	20	510	290	800

Note: ESE for

- PHY1401 & BIC1401 will be conducted for 50 marks and normalized to 70 marks for grading.
- NMT1401, NMT1402 and NMT1403 will be conducted for 100 marks and scaled to 50 marks for grading.
- IAC for NMT1404, EIC1501 & CSK1501 will be conducted for 50 marks and normalized to 100 marks for grading.

SEMESTER III

Course Code	Course title	Credit distribution (L,T,P, CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
NMT2301	Introduction to Radiopharmacy	3	1	-	-	4	50	50	100
NMT2302	Nuclear Medicine Instrumentation Physics	3	1	-	-	4	50	50	100
NMT2303	Mathematics in Nuclear Medicine	2	1	-	-	3	50	50	100
NMT2304	Practicum - III	-	1	6	-	4	50	50	100
NMT2305	Clinical Practice	-	1	-	3	2	100	-	100
*** **	Open Elective - I	2	1	-	-	3	S/NS		
	Total	10	6	6	3	20	300	200	500

Note: ESE for

- NMT2301, NMT2302, NMT2303 and NMT2304 will be conducted for 100 marks normalized to 50 marks for grading.
- IAC for, NMT2305 will be conducted for 50 marks and normalized to 100 marks for grading.

SEMESTER IV

Course Code	Course title	Credit distribution (L,T,P, CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
BST3401	Biostatistics and Research methodology	3	-	-	-	3	30	70	100
NMT2401	Radiobiology	2	1	-	-	3	50	50	100
NMT2402	Health Physics	2	1	-	-	3	50	50	100
NMT2403	Practicum-IV	-	1	4	-	3	50	50	100
NMT2404	Clinical practice	-	1	-	12	5	100	-	100
NMT***	Program Elective I	2	1	-	-	3	50	50	100
	Total	9	5	4	12	20	330	270	600

Note: ESE for

- BST3401, will be conducted for 100 marks and normalized to 70 marks for grading.
- NMT2401, NMT2402 and NMT2403 will be conducted for 100 marks and scaled to 50 marks for grading

SEMESTER V

Course Code	Course title	Credit distribution (L,T,P, CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
NMT3301	Radiopharmacy in Nuclear Medicine	3	1	-	-	4	50	50	100
NMT3302	Therapeutic Nuclear Medicine	2	1	-	-	3	50	50	100
NMT3303	Clinical Nuclear Medicine -I	3	1	-	-	4	50	50	100
NMT3304	Practicum –V	–	1	4	-	3	50	50	100
NMT3305	Clinical Practice	-	1	-	6	3	100	-	100
*** **	Open Elective - II	-	-	-	-	3	S/SN		
	Total	8	5	4	6	20	300	200	500

Note: ESE for

- NMT3301, NMT3302, NMT3303 and NMT3304 will be conducted for 100 marks and normalized to 50 marks for grading.

SEMESTER VI

Course Code	Course title	Credit distribution (L,T,P,CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
NMT3401	Tomography and hybrid imaging	3	1	-	-	4	50	50	100
NMT3402	Clinical Nuclear Medicine-II	3	1	-	-	4	50	50	100
NMT3403	Practicum-VI	-	2	4	-	4	50	50	100
NMT3404	Clinical Practice	-	1	-	12	5	100	-	100
NMT ***	Program Elective-II	2	1	-	-	3	50	50	100
	Total	8	6	4	12	20	300	200	500

Note: ESE for

- NMT3401, NMT3402 and NMT3403 will be conducted for 100 marks and normalized to 50 marks for grading.

Open Electives

Open elective is credited, choice-based and is graded as satisfactory/not satisfactory (S/NS). Students make a choice from pool of electives offered by MAHE institutions/online courses as approved by the department.

Program Electives

Program elective is credited and choice-based. The students make a choice from pool of electives offered by the department. The ESE is conducted for 50 marks.

PROGRAM ELECTIVE - I (Semester IV)

Course Code	Elective title	Credit distribution (L,T,P,CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
NMT2405	Non-Imaging Nuclear Medicine Techniques	2	1	-	-	3	50	50	100
NMT2406	Radio-immunology								

PROGRAM ELECTIVE - II (Semester VI)

Course Code	Elective title	Credit distribution (L,T,P,CL are hours/week)					Marks Distribution		
		L	T	P	CL	CR	IAC	ESE	Total
NMT3405	Principles and Techniques in Radiopharmaceutical Development	2	1	-	-	3	50	50	100
NMT3406	Principles and Techniques in Nuclear Medicine Image Analysis								

SEMESTER – VII and VIII
Internship (1 year, 48 hour/week)

SEMESTER VII		SEMESTER VIII	
Course	Duration	Course	Duration
Internship	6 months	Internship	6 months
Total	12 months (CL=48 hours / week)		

TOTAL DEGREE CREDIT DISTRIBUTION

Semester	Credit distribution (L,T,P are hours/week)					Marks Distribution		
	L	T	P	CL	C	IAC	ESE	Total
Semester - I	10	4	12	-	20	310	290	600
Semester - II	14	3	4	3	20	510	290	800
Semester - III	10	6	6	3	20	300	200	500
Semester - IV	9	5	4	12	20	330	270	600
Semester - V	8	5	4	6	20	300	200	500
Semester - VI	8	6	4	12	20	300	200	500
Semester - VII Internship	-	-	-	48	-	-	-	-
Semester - VIII Internship	-	-	-	48	-	-	-	-
Total					120	2050	1450	3500

SEMESTER - I

COURSE CODE : COURSE TITLE

ANA1303 : Anatomy

PHY1301 : Physiology - I

NMT1301 : Fundamentals of Electronics

NMT1302 : Radiation Physics

NMT1303 : Practicum - I

NMT1304 : Lab Practice

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Anatomy
Course Code	ANA1303
Academic Year	First
Semester	I
Number of Credits	3
Course Prerequisite	Basic knowledge of biology
Course Synopsis	Human anatomy is the study of gross features and relations of various structures of the human body by dissection.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain the General Anatomy, respiratory, system of the human body (C1, C2)
CO2	Explain the cardiovascular, digestive system of the human body (C1, C2)
CO3	Explain the excretory, reproductive system of the human body (C1, C2)
CO4	Explain the endocrine, central nervous system, special senses of the human body (C1, C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x							
CO4	x							

Course Content and Outcomes

Content	Competencies	Number of Hours (Theory):
Unit 1:		
General Anatomy	<ul style="list-style-type: none"> • Define the Anatomical position and Anatomical terms (C1) • Explain the epithelium - types and functions (C2) • Explain the connective tissue–fibers and cells (C2) • Explain the cartilage- types, structure and function(C2) • Explain the bone - types, structure and blood supply (C2) • Explain the muscle - classification, structure and function (C2) 	7

Content	Competencies	Number of Hours (Theory):
	<ul style="list-style-type: none"> • Explain the neurons- types and structure, typical spinal nerve (C2) • Explain the blood vessels–arteries, veins, lymph vessels, lymph nodes, structure of lymph node (C2) • Explain the joints: Classification, examples , structure of a typical synovial joint (C2) • Ex plain the classification of synovial joints (C2) 	
Unit 2:		
Respiratory system	<ul style="list-style-type: none"> • List the parts of respiratory tract (C1) • Explain the boundaries of the Nasal cavity (C2) • Explain the Lateral wall of nasal cavity - features, blood supply, nerve supply and lymphatic drainage(C2) • Explain the nasal septum: Formation, blood supply, nerve supply, lymphatic drainage and applied anatomy (C1, C2) • List and Explain the paranasal air sinuses and their function (C1, C2) • Explain the pharynx - extent, parts- nasopharynx, oropharynx and laryngopharynx - internal features (C2) • Explain the cavity of larynx, blood supply, nerve supply (C1, C2) • Explain the vocal cords and their movements, and Rima glottidis (C2) • List the intrinsic muscles of the larynx, their nerve supply and actions (C1) • List the Cartilaginous framework and ligaments (C1) • Explain the trachea: Extent, Structure and nerve supply (C2) • Explain the diaphragm - attachments, nerve supply and actions (C2) • Explain the thoracic cage: thoracic wall, intercostal spaces and their contents (C1, C2) • Explain the Lungs- gross anatomy, roots of the lungs, surface marking of pleura and lungs (C1, C2) • Explain the pleura- parts, pleural cavity, pleural recesses, pulmonary ligament (C2) 	5
Unit 3:		
Cardiovascular system	<ul style="list-style-type: none"> • Explain the heart - position, external features, right atrium internal features (C1, C2) 	4

Content	Competencies	Number of Hours (Theory):
	<ul style="list-style-type: none"> • Explain the right ventricle internal features, Blood supply to the heart (C1, C2) • Explain the left atrium and left ventricle, nerve supply of heart (C2) • Explain the pericardium - Parts, blood supply, nerve supply and function (C2) • Explain the mediastinum - boundaries and contents (C2) • List and explain the arteries - Arch of aorta and descending thoracic aorta (extent course and branches) (C1, C2) • Explain the veins -Azygos system of vein (formation, course and termination) (C1, C2) • Define the thoracic duct: formation, course and termination (C2) • Explain the arteries - pulmonary trunk, ascending aorta (extent course and branches) (C2) • Explain the veins - branchiocephalic veins, superior vena cava (formation, course and termination) (C2) • Explain the major arteries and veins of head and neck (name and positions) (C2) • Explain the major arteries and veins of abdomen and pelvis (name and positions) (C2) • Explain the abdominal aorta, inferior vena cava, portal vein (C1, C2) 	
Unit 4:		
Digestive system	<ul style="list-style-type: none"> • List the parts of digestive system (C1) • Explain the tongue–gross anatomy, blood supply and nerve supply (C2) • Explain the salivary glands- Names and location (C2) • Explain the oesophagus- extent, parts, constrictions, blood supply, nerve supply and lymphatic drainage (C2) • Explain the stomach- position, relations, blood supply, nerve supply and lymphatic drainage (C1, C2) • Explain the duodenum- parts, important relations, blood supply and nerve supply (C2) • Explain the pancreas–position, parts, important relations, blood supply and nerve supply (C2) • Explain the small intestine–parts- duodenum, jejunum and ileum- blood supply and nerve 	6

Content	Competencies	Number of Hours (Theory):
	supply (C1, C2) <ul style="list-style-type: none"> • Explain the large intestine—parts, position of each of the parts, extent, blood supply and nerve supply (C2) • List the differences between jejunum and ileum (C1) • List the differences between small intestine and large intestine (C1) • Explain the rectum and anal canal—position, blood supply, nerve supply and lymphatic drainage (C2) • Explain the liver- position, anatomical and physiological lobes, surfaces, relations, porta hepatis, blood supply and nerve supply (C1, C2) • Explain the extrahepatic biliary apparatus—gall bladder and bile duct (C2) 	
Unit 5:		
Urinary system	<ul style="list-style-type: none"> • List the parts of urinary system (C1) • Explain the kidneys: position, external features, capsules, relations, macroscopic structure, blood supply and nerve supply (C1, C2) • Explain the ureter- length, constrictions and blood supply (C2) • Explain the urinary bladder- position, external features, blood supply and nerve supply (C2) • Explain the urethra- female urethra, male urethra- parts (C2) 	2
Unit 6:		
Male reproductive system	<ul style="list-style-type: none"> • List the parts of male reproductive system (C1) • List the spermatic cord- constituents and coverings (C1) • Explain the testes- position, coverings, gross structure, blood supply, nerve supply and lymphatic drainage (C2) • Explain the vas deferens- commencement, course and termination (C2) • Explain the prostate—position, external features, lobes and structure (C2) • Explain the seminal vesicles and ejaculatory ducts (C2) 	2
Unit 7:		
Female reproductive system	<ul style="list-style-type: none"> • Name the parts of female reproductive system (C1) • Explain the uterus—position, parts, external 	2

Content	Competencies	Number of Hours (Theory):
	features, relations, blood supply and lymphatic drainage (C2) <ul style="list-style-type: none"> • Explain the uterine tube- parts, blood supply and nerve supply (C2) • Explain the ovary – position and structure (C2) 	
Unit 8:		
Endocrine glands	<ul style="list-style-type: none"> • Name the endocrine glands (C1) • Explain the pituitary gland (Hypophysis cerebri)- position, parts, blood supply (C2) • Explain the suprarenal glands- position, relations, parts, blood supply and lymphatic drainage (C2) • Explain the thyroid gland- position, parts, blood supply and lymphatic drainage (C2) • Name the parathyroid glands-their position and blood supply (C1) 	2
Unit 9:		
Central Nervous system	<ul style="list-style-type: none"> • Name the parts of the CNS (C1) • List the features and explain the spinal cord- position, external features, internal structure, brief note on important ascending and descending tracts (C1, C2) • Explain the major motor and sensory pathways (C2) • Explain the pyramidal tract in detail (C2) • Name the parts of brain (C2) • List the external and internal features of medulla oblongata (C1) • List the cranial nerves attached to medulla oblongata(C1) • List the external and internal features pons (C1) • Explain the cranial nerves attached to pons and ponto-medullary junction (C2) • Explain the cerebellum- functional lobes of the cerebellum and its functions (C2) • Explain the midbrain- external features and internal structure–in brief (C1) • Explain the cranial nerves attached to midbrain (C2) • Explain the cerebral hemispheres–lobes, important sulci and functional areas (C2) • List the fiber system of the brain and explain the corpus callosum and internal capsule (C1, C2) • Explain the diencephalon- Thalamus and 	12

Content	Competencies	Number of Hours (Theory):
	hypothalamus-position and functions (C2) <ul style="list-style-type: none"> • Explain the basal nuclei: Corpus striatum-parts and functions (C2) • Explain the blood supply to the central nervous system (C2) • Explain the ventricles: 4th and 3rd ventricles (features, position and communications) (C2) • Explain the lateral ventricles- parts, features, position and communications (C2) • Define the CSF production and circulation (C1) 	
Unit 10:		
Special senses	<ul style="list-style-type: none"> • Recall the gross anatomy of the eye (C1) • Recall the gross anatomy of external, middle and internal ear (C1) • Recall the skin and its features (C1) 	3

Learning Strategies, Contact Hours and Out of class engagement				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	45	45		
Total	45	45		
Assessment Methods:				
Formative:		Summative:		
Nil		Sessional Exam I / Sessional Exam II (Theory)		
		End Semester Exam (Theory)		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Sessional Examination 1	x	x		
Sessional Examination 2			x	x
End Semester Exam	x	x	x	x
Feedback Process:	End-Semester Feedback			
Main Reference:	1. Manipal Manual of Anatomy by Dr. Sampath Madhyastha			
Additional References	1. Human Anatomy by Dr. B. D. Chaurasia (Vol 1,2,3,4) 2. Chaurasia's handbook of human anatomy 3. Netter's Atlas			

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Physiology - I
Course Code	PHY1301
Academic Year	First
Semester	I
Number of Credits	2
Course Prerequisite	Basic knowledge of biology
Course Synopsis	This module provides a comprehensive knowledge about normal functions of the organ systems of the body to understand the physiological basis of health and disease required for health professional (paramedical) courses.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain the various transport mechanisms across the cell membrane, composition and distribution of body fluids, components of blood and their functions, blood groups, blood coagulation and the basis for related diseases. (C1, C2)
CO2	Describe the morphology and functions of nerve and muscles. (C1, C2)
CO3	Explain the functions of cardiovascular and respiratory systems to facilitate the understanding of health & disease process (C1, C2)
CO4	Describe the physiology of special sense organs and the related disease process (C1, C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x							
CO4	x							

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1. BASIC CONCEPTS AND NERVE PHYSIOLOGY		
Transport across cell membrane	<ul style="list-style-type: none"> Name the various transport mechanisms across cell membrane(C1) Describe passive transport mechanisms such as simple diffusion, facilitated diffusion and osmosis (C2) Describe primary and secondary active transport mechanisms(C2) 	4

Content	Competencies	Number of Hours
Body fluid compartments	<ul style="list-style-type: none"> • Mention the total body water as percentage of body weight and its distribution. (C1) • Give the ionic composition of body fluids(C1) 	
Physiology of neuron	<ul style="list-style-type: none"> • Describe the morphology of a neuron (C2) • Mention the structure and functions of myelinated and unmyelinated nerve fibers (C2) 	
Membrane potential	<ul style="list-style-type: none"> • Describe resting membrane potential(C2) • Draw and label the action potential (C2) • Describe the ionic basis of the action potential (C2) 	
Unit 2: MUSCLE PHYSIOLOGY		
Skeletal muscle	<ul style="list-style-type: none"> • Describe the characteristic features of skeletal, cardiac and smooth muscles(C2) • Describe the structure of skeletal muscles(C2) • Mention the types of skeletal muscles(C1) • Explain neuromuscular transmission in skeletal muscle(C2) • Explain excitation contraction coupling in skeletal muscle(C2) • Describe rigor mortis (C2) 	4
Smooth muscle	<ul style="list-style-type: none"> • Mention the types of smooth muscle(C1) 	
Unit 3: BLOOD		
Composition and functions of blood	<ul style="list-style-type: none"> • Describe the composition of blood(C2) • List the functions of blood (C1) 	6
Plasma proteins	<ul style="list-style-type: none"> • Name the different types of plasma proteins (C1) • List the functions of plasma proteins(C1) 	
Red blood cells	<ul style="list-style-type: none"> • Mention the morphology and functions of red blood cells (C1) • Mention the normal count of RBC and its variations (C1) • Describe the sites, stages and factors influencing erythropoiesis(C2) • Mention the normal value of hemoglobin concentration and its variations (C1) • Mention the functions of hemoglobin (C1) • Define anemia and describe the morphological classification of anemia (C1, C2) 	
White blood cells	<ul style="list-style-type: none"> • Classify White Blood Cells (WBC) (C2) • List the functions of WBCs(C1) • Mention the normal count of various types of WBCs (C1) 	

Content	Competencies	Number of Hours
Hemostasis	<ul style="list-style-type: none"> • Mention the normal range of platelets and its variations(C1) • List the functions of platelets(C1) • Define hemostasis(C1) • Describe the various stages involved in haemostasis (C2) • List the clotting factors(C1) • Describe the intrinsic and extrinsic pathways of coagulation (C2) • Describe hemophilia(C2) • Classify anticoagulants and give examples for each(C2) 	
Blood types/groups	<ul style="list-style-type: none"> • State Landsteiner's law (C1) • Describe the ABO and Rh systems of blood grouping(C2) • Explain the importance of blood grouping(C2) • Mention the hazards of blood transfusion(C1) • Explain the cause and clinical features of hemolytic disease of the newborn (erythroblastosis fetalis) (C2) 	
Lymph	<ul style="list-style-type: none"> • List the functions of lymph (C1) 	
Unit 4: CARDIOVASCULAR SYSTEM		
Organization of cardiovascular system	<ul style="list-style-type: none"> • Describe the structure of heart (C2) • Describe the innervation of heart and blood vessels(C2) • Describe the properties of cardiac muscle (C2) 	9
Cardiac cycle	<ul style="list-style-type: none"> • Define cardiac cycle (C1) • State the normal duration of cardiac cycle (C1) • Describe the left ventricular pressure and volume changes during a cardiac cycle(C2) 	
Heart sounds	<ul style="list-style-type: none"> • Enumerate the differences between first and second heart sounds(C2) 	
Electrocardiogram (ECG)	<ul style="list-style-type: none"> • Define electrocardiogram (ECG) (C1) • Draw a labeled diagram of a normal ECG recorded from limb lead II (C1) • Describe the waves and intervals of ECG (C2) • Mention the uses of ECG (C1) 	
Heart rate	<ul style="list-style-type: none"> • Mention the normal value and variations of heart rate(C1) 	
Cardiac output	<ul style="list-style-type: none"> • Define cardiac output (C1) • State the normal value of cardiac output (C1) • Mention the variations of cardiac output(C1) • Describe the regulation of cardiac output(C2) 	

Content	Competencies	Number of Hours
Blood pressure (BP)	<ul style="list-style-type: none"> Define blood pressure (BP) (C1) Mention the normal value of BP (C1) Mention the factors influencing BP(C1) Mention the variations of blood pressure(C1) Describe the short term regulation of arterial blood pressure(C2) 	
Unit 5: RESPIRATORY SYSTEM		
Introduction to respiration	<ul style="list-style-type: none"> Describe the functional anatomy of the respiratory system (C2) 	6
Mechanics of Respiration	<ul style="list-style-type: none"> Mention the muscles of respiration(C1) Describe the mechanism of inspiration and expiration(C2) Describe the intra-pulmonary and intra-pleural pressure changes during the various phases of respiration(C2) 	
Lung volumes and capacities	<ul style="list-style-type: none"> Draw a labelled spirogram(C2) Define various lung volumes and capacities (C1) Mention the normal values of lung volumes and capacities (C1) 	
Ventilation	<ul style="list-style-type: none"> Define pulmonary ventilation (C1) Mention the normal value of pulmonary ventilation (C1) Define alveolar ventilation(C1) Mention the normal value of alveolar ventilation(C1) Define anatomical dead space (C1) Mention the normal value of anatomical dead space (C1) 	
Gas exchange	<ul style="list-style-type: none"> Describe the structure of respiratory membrane (C2) Mention the factors affecting diffusion of gases across it (C1) 	
Transport of gases	<ul style="list-style-type: none"> Mention the forms in which oxygen is transported in the blood(C1) Describe the oxygen-hemoglobin dissociation curve(C2) Mention the factors shifting the oxygen-hemoglobin dissociation curve to the right and to the left(C1) Mention the forms in which carbon dioxide is transported in the blood(C1) Describe the mechanism of carbon dioxide transport(C2) 	

Content	Competencies	Number of Hours
Regulation of respiration	<ul style="list-style-type: none"> • Explain the neural regulation of respiration(C2) • Explain the chemical regulation of respiration(C2) 	
Applied aspects	<ul style="list-style-type: none"> • Define hypoxia(C1) • Mention the types of hypoxia with example (C1) • Define cyanosis(C1) • Mention the cause of cyanosis (C1) • Define apnea, dyspnea and asphyxia(C1) 	
Unit 6: SPECIAL SENSES		
Vision	<ul style="list-style-type: none"> • Describe the structure of human eye with the help of a diagram (C2) • Mention the functions of aqueous humor (C1) • Name the photoreceptors (C1) • Mention the differences between the rods and cones (C1) • Draw the visual pathway (C2) • Explain the defects in field of vision due to lesions of visual pathway at different locations (C2) • Describe the mechanism of accommodation(C2) • Describe light reflex with the help of a diagram(C2) • Define visual acuity and mention the tests (C2) • Describe the cause and correction for refractory errors of the eye(C2) 	4
Hearing and vestibular apparatus	<ul style="list-style-type: none"> • Describe the structure and functions of external, middle and inner ear (C2) • Describe the mechanism of hearing (C2) • Mention the parts and functions of vestibular apparatus (C1) 	
Taste and smell	<ul style="list-style-type: none"> • Name the receptors for taste and smell (C1) • Mention the disorders of taste and smell (C1) 	

Learning Strategies, Contact Hours and Out of class engagement		
Learning Strategies	Contact Hours	Out of class engagement
Lecture	33	33
Revision	4	4
Total	37	37
Assessment Methods:		
Formative:	Summative:	
Nil	Sessional Exam I / Sessional Exam II (Theory)	
	End Semester Exam (Theory)	

Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Sessional Examination 1	x	x	-	-
Sessional Examination 2	-	-	x	x
End Semester Exam	x	x	x	x
Feedback Process:	End-Semester Feedback			
Main Reference:	1. Basics of Medical Physiology, 4 th edition, D.Venkatesh, H.H.Sudhakar			

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Fundamentals of Electronics						
Course Code		NMT1301						
Academic Year		First						
Semester		I						
Number of Credits		3						
Course Prerequisite		Basic Knowledge of physics						
Course Synopsis		This module will serve a bridge between basic electronics and Nuclear Medicine instrumentation.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Explain the basic definition and concept of electronics (C2)							
CO2	Explain the use and working of electronic components and circuits used in radiation equipment. (C3)							
CO3	Explain electronic circuitry of medical imaging devices.(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x	x						

Course Content and Outcomes

Content	Competencies	Number of Hours
Unit 1		
Circuit components	1. What are Resistors, Capacitors?(C1) 2. Define Inductors, Transformers. (C1) 3. Define Ohm's Law and Kirchhoff's Law (C1)	2
Theory of Semiconductors	1. Define the atomic structure of semiconductor (C1) 2. Classify the material on the basis of energy Band (C2) 3. Explain the types of semiconductor (C2) 4. Explain diode and its use (C2 & C3) 5. Explain triode and its use (C2 & C3) 6. Explain unipolar transistor and its use (C2 & C3)	6
Digital Electronics	1. Define Digital Electronics and Number systems (C1) 2. Explain Logic gates. (C2)	2

Content	Competencies	Number of Hours
Unit 2		
Amplifiers	<ol style="list-style-type: none"> 1. Define Amplifiers and Explain the types of amplifiers and its characteristics (C1 &C2) 2. Define Pre amplifier and Explain pre amplifier.(C1 &C2) 3. Explain Operational Amplifiers (C2) 4. Classify the operational amplifier (C2) 5. Operational amplifier application in Nuclear Medicine(C3), 6. Use of Comparators in Nuclear Medicine (C3) 	7
Rectifiers	<ol style="list-style-type: none"> 1. What is Rectifier? And Explain types of rectifiers (C1&C2) 2. What are Transducers? Explain application of transducers in Nuclear Medicine. (C1 &C2) 3. Explain CRT and its use in Nuclear Medicine (C2) 4. Explain LED (C2) 	4
Power supply	<ol style="list-style-type: none"> 1. Define Power supply. List types of Power supply (C1) 2. Explain voltage stabilizer (C2) 3. Demonstrate the use of voltage stabilizer in Nuclear Medicine (C2) 4. Explain the Converter; Inverter; voltage regulator; SMPS (C2) 5. Demonstrate the use of Converter; Inverter; voltage regulator; SMPS in Nuclear Medicine. (C2) 6. Explain UPS (C2) 7. Define and explain the characteristics of ADC and DAC (C1 &C2) 	10
Unit 3		
Filter circuits	<ol style="list-style-type: none"> 1. What are Filter circuits (C1) 2. Explain types of filter (C2) 3. Explain low pass, high Pass and band pass filters (C2) 4. Demonstrate the use of low pass, high Pass, band pass filters in Nuclear Medicine (C2) 5. Application of filters in Image reconstruction(C3) 	5
Pulse shaping	<ol style="list-style-type: none"> 1. What is pulse shaping (C1) 2. Explain Pulse shaping (C2) 3. Demonstrate pulse shaping in nuclear medicine appliances(C2) 4. Define Noise (C1) and Explain noise correction methods in nuclear Medicine (C2) 5. Explain Pulse height Analyser(C2) 	5

Content	Competencies	Number of Hours
Circuits	1. Explain coincidence circuit and anti-coincidence circuit? (C2) 2. Explain the application of coincidence circuit and anti-coincidence circuit in Nuclear Medicine?(C2)	4

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	30
Seminar	10	10
Revision	3	3
Assessment	2	2
Total	45	45

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester Exam (Theory)
Quiz	End Semester Exam (Theory)
Assignments/Presentations	

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3
Mid Semester Examination	x	x	-
Quiz / Viva/ Unit Test	x	x	x
Assignments/Presentations	x	x	x
End Semester Exam	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback
Main Reference:	1. Nuclear Medicine Physics by Ramesh Chandra 2. Nuclear Medicine Physics by Sorenson 3. Basic Physics in Nuclear Medicine by Gopal B.Saha
Additional References	1. Principle Medical Electronics and Biomedical by Instrumentation by R.C Rajan, Guha S K 2. Electronics and Instrumentation by Gupta B.R. 3. Integral Electronics- Analogue and Digital Circuits system by Millman Jacob, Halkias Christor C .

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of science in Nuclear Medicine Technology							
Course Title	Radiation Physics							
Course Code	NMT1302							
Academic Year	First							
Semester	I							
Number of Credits	4							
Course Prerequisite	Basic knowledge of physics							
Course Synopsis	This module provides fundamental knowledge of radioactive decay process, interaction of ionizing radiations with matter, detection of ionizing radiations, nuclear reactions and production of medical radionuclides.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand basics of nuclear physics(C2)							
CO2	Explain physics behind radiation phenomenon (C2)							
CO3	Apply and analyze radiation phenomenon in situations related to nuclear medicine(C2)							
CO4	Enlist different types of nuclear reactions(C2)							
CO5	Explain interaction of ionizing radiation with matter(C2)							
CO6	Apply and analyze interaction of ionizing radiation with matter in nuclear medicine instrumentation and biology(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x	x						
CO4	x							
CO5	x							
CO6	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Modern Physics	1. List particle properties of waves and different types of electromagnetic waves (C1) 2. Explain production of x-rays (C2) 3. Explain x-ray diffraction process (C2) 4. Explain Rutherford's and Bohr's atomic model (C2)	06

Content	Competencies	Number of Hours
	5. Explain wave properties of matter: de Broglie waves, uncertainty principle (C2) 6. Demonstrate working of electron microscope (C2)	
Radioactivity	1. Discuss composition of atomic nucleus, stability of nucleus, binding energy and fate of unstable nucleus (C2) 2. Explain radioactivity, Decay modes, decay by beta emission, decay by beta-gamma emission, isomeric transition and internal conversion, decay by EC-gamma emission, positron-gamma decay, decay by alpha emission (C2) 3. List properties of alpha, beta, gamma, positrons, neutrons, x rays (C1) 4. Explain beta spectrum (C2) 5. Define radioactivity and decay constant (C1) 6. List units of radioactivity (C1) 7. Define laws of radioactivity (C1) 8. Derive and analyse radioactivity equation (C3) 9. Analyse radioactivity equation (C4) 10. Define and derive radioactive half-life (C3) 11. Apply and analyse half-life (C4) 12. Explain specific activity (C2) 13. Apply specific activity in nuclear medicine situations (C3) 14. Explain decay of mixed radionuclide samples 15. Apply concept of decay of mixed radionuclide samples in hypothetical situations in nuclear medicine (C3) 16. Explain parent-daughter decay (C2)	16
Unit 2:		
Nuclear reactions and production of radionuclides	1. Illustrate nuclear reactions and nuclear energy levels; Nuclear isomerism, Bombardment (C2) 2. Explain fission and fusion reaction (C2) 3. List various types of nuclear reactors (C1) 4. Explain design of a nuclear reactor (C2) 5. List different types of medical cyclotrons (C1) 6. Explain design and working of medical cyclotron (C2) 7. Explain methods for production of radioisotopes in a medical cyclotron (C2)	11
Interaction of Radiation with matter	1. Explain interaction of charged particle with matter: Collisional and radiative losses (C2) 2. Explain charged particles track (C2) 3. Define cerenkov effect (C1) 4. Explain, apply and analyse photoelectric effect	15

Content	Competencies	Number of Hours
	(C4) 5. Explain, apply and analyse Compton scattering (C4) 6. Explain, apply and analyse Pair production (C4) 7. Explain, apply and analyse Bremsstrahlung radiation (C4) 8. Define coherent scattering (C1) 9. Explain Importance of radiation attenuation in radiology and nuclear medicine (C2) 10. Explain transmission of high energy radiation through matter (LET); Linear and Mass attenuation coefficients (cross section curves wrt. Gamma energy and atomic number) (C2) 11. Apply linear and mass attenuation coefficients in nuclear medicine situations (C3)	
Unit 3:		
Radiation detection and Measurement	1. Units of radiation exposure (C2) 2. Different types of radiation detectors (C1) 3. Principle of radiation detection by Gas filled detectors (C2) 4. Principle of radiation detection by inorganic scintillator detectors (C2) 5. Principle of radiation detection by organic scintillator detectors (C2) 6. Principle of radiation detection by semiconductor detectors (C2)	12

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	45	45
Seminar	11	11
Revision	2	2
Assessment	2	2
Total	60	60

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester Exam (Theory)
Quiz	End Semester Exam (Theory)
Assignments / Presentations	

Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	X	X	X	-	-	-
Quiz / Viva/ Unit Test	X	X	X	X	X	X
Assignments/Presentations	X	X	X	X	X	X
End Semester Exam	X	X	X	X	X	X
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Concepts of Modern Physics- Arthur Bieser 2. Physics in Nuclear Medicine- Sorenson 3. Nuclear Medicine Physics- Ramesh Chandra					
Additional References	1. Essential Nuclear medicine Physics- Rachel A. Powsner, Edward R. Powsner 2. Introductory Nuclear Physics- Krane K. S. 3. Radiation Detection and Measurement- Knoll G. F.					

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of science in Nuclear Medicine Technology							
Course Title	Practicum - I							
Course Code	NMT1303							
Academic Year	First							
Semester	I							
Number of Credits	4							
Course Prerequisite	Basic knowledge of electronics and physics							
Course Synopsis	This module provides practical aspects in electronics, interaction of radiation with matter, handling of oscilloscope, GM counter and gamma-ray spectrometer.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	To understand practical aspects of electronics (C2, P4)							
CO2	To understand fundamental knowledge of operating oscilloscope, gamma ray spectrometer and GM Counter(C2, P4)							
CO3	To understand how radiation interacts with matter(C2, P4)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Fundamentals of Electronics Practicals	1. To demonstrate the working of a digital multimeter (C2) (P4) 2. To measure resistance of given set of resistors using digital multimeter and compare with colour coding values (C2) (P4) 3. To measure capacitance of given set of capacitors using digital multimeter and compare with calibrated values (C2) (P4) 4. To demonstrate the testing of diodes using digital multimeter (C2) (P4) 5. To measure voltage output from a given source using digital multimeter and find error in the measured values (C2) (P4) 6. To demonstrate working of different parts of an oscilloscope (C2) (P4)	40

Content	Competencies	Number of Hours
	7. To measure voltage signal using digital oscilloscope (C2) (P4) 8. To measure frequency of incoming signal using digital oscilloscope (C2) (P4) 9. To demonstrate the operation of low pass filter using oscilloscope (C2) (P4) 10. To demonstrate the operation of high pass filter using oscilloscope (C2) (P4)	
Unit 2		
Radiation physics Practicals	1. To demonstrate functioning of various parts of a gamma ray spectrometer (C2) (P1) 2. To observe the gamma ray energy spectrum of Cs-137 radioisotopes and identify various types of processes (C2) (P1) 3. To observe the gamma ray energy spectrum of Ba-133 radioisotopes and identify various types of processes (C2) (P1) 4. To observe the gamma ray energy spectrum of Tc-99m radioisotopes and identify various types of processes (C2) (P1) 5. To observe the gamma ray energy spectrum of I-131 radioisotopes and identify various types of processes (C2) (P1) 6. To demonstrate working of a NaI(Tl) detector and observe its output on an oscilloscope (C2) (P1) 7. To demonstrate the effect of magnetic field on beta and gamma radiations (C2) (P1) 8. To determine the half-life of a given radioisotope (C5) (P4) 9. To determine the half value layer of lead for Ba-133 (C5) (P4) 10. To determine the half value layer of lead for Cs-137 (C5) (P4) 11. To determine the half value layer of lead for Tc-99m (C5) (P4) 12. To determine the half value layer of copper for Ba-133 (C5) (P4) 13. To determine the half value layer of copper for Cs-137 (C5) (P4) 14. To determine the half value layer of copper for Tc-99m (C5) (P4) 15. To determine the half value layer of aluminium for Ba-133 (C5) (P4) 16. To determine the half value layer of aluminium for Cs-137 (C5) (P4) 17. To determine the half value layer of aluminium for Tc-99m. (C5) (P4)	65

Learning Strategies, Contact Hours and Out of class engagement:			
Learning Strategies	Contact Hours	Out of class engagement	
Lecture	15	15	
Practical	80	80	
Revision	6	10	
Assessment	4	0	
Total	105	105	
Assessment Methods:			
Formative:		Summative:	
Unit Test		Mid Semester/Sessional Exam (Practical)	
Quiz		End Semester Exam (Practical)	
Viva		Viva	
Practical Log Book/ Record Book		Record Book	
Mapping of Assessment with COs:			
Nature of Assessment	CO1	CO2	CO3
Mid Semester	x	x	x
Quiz / Viva/ Unit Test	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x
End Semester Exam	x	x	x
Feedback Process:	Mid-Semester Feedback		
	End-Semester Feedback		
Main Reference:	1. Principle Medical Electronics and Biomedical Instrumentation by R.C Rajan, Guha S K 2. Physics in Nuclear Medicine by Sorenson 3. Quality control of Nuclear Medicine instruments by Tecdoc 602		
Additional References	1. Radiation Detection and Measurement- Knoll G. F. 2. Introductory Nuclear Physics- Krane K. S.		

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of science in Nuclear Medicine Technology							
Course Title	Lab Practice							
Course Code	NMT1304							
Academic Year	First							
Semester	I							
Number of Credits	4							
Course Prerequisite	Basic understanding on hospital procedures, first aid, radiation and non-radiation equipment.							
Course Synopsis	This module provides overview of various nuclear medicine procedures, care of patients, drugs, laboratory items and equipment available in the department.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	List various hospital procedures(C1)							
CO2	List principles of care of patients(C1)							
CO3	List principle of asepsis(C1)							
CO4	Illustrate drugs in nuclear medicine (C1)							
CO5	Identify common lab items and equipment (C1)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x			x				
CO3	x							
CO4	x							
CO5	x							

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Hospital procedure	1. List of various hospital procedures (C1) 2. List various in vivo and in vitro Nuclear Medicine Procedures (C1)	22
Care of the patient	1. List Information given to the patients undergoing various Nuclear Medicine procedures (C1)	14
First aid	1. List of first aid items (C1) 2. List of emergency items in the Nuclear Medicine department (C1)	22
Unit 2		
Principles of asepsis	What are all precautions and procedures adopted in nuclear medicine to ensure asepsis? (C1)	13

Content	Competencies	Number of Hours
Drugs in the department	List common drugs available in nuclear medicine department and its application (C1)	13
Acquaintance of equipment	List the various radiation/non-radiation equipment/devices available in Nuclear Medicine department. Also enlist their use (C1)	21

Learning Strategies, Contact Hours and Out of class engagement:					
Learning Strategies	Contact Hours	Out of class engagement			
Lecture	15	15			
Practical	90	90			
Total	105	105			
Assessment Methods:					
Formative:			Summative:		
Unit Test			Mid Semester exam (Practical)		
Quiz			Viva		
Viva			Record Book		
Assignments/Presentations					
Clinical/Practical Log Book/ Record Book					
Mapping of Assessment with COs:					
Nature of Assessment	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	x	x	x	x	x
Quiz / Viva/ Unit Test	x	x	x	x	x
Assignments/Presentations / Clinical/ Practical Log Book/ Record Book	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback				
Main Reference:	1. Care of patient in diagnostic Radiography By: Chesney & Chesney. 2. Chesney's Care of the patient in Diagnostic Radiography By: Pauline J . Culmer.				
Additional References	1. Aid to Tray and Trolley Setting By: Marjorie Houghton 2. Physis in Nuclear Medicine By Sorenson				

SEMESTER - II

Course code	:	Course Title
PHY1401	:	Physiology - II
BIC1401	:	Biochemistry
EIC1501	:	Environmental Science and Indian Constitution
CSK1501	:	Communication Skills
NMT1401	:	Cell and Molecular Biology
NMT1402	:	Bioethics and Patient Care
NMT1403	:	Practicum - II
NMT1404	:	Clinical Practice

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Physiology - II
Course Code	PHY1401
Academic Year	First Year
Semester	II
Number of Credits	2
Course Prerequisite	Basic knowledge of general physiology
Course Synopsis	This module provides a comprehensive knowledge about normal functions of the organ systems of the body to understand the physiological basis of health and disease required for health professionals.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain the physiology of central nervous system in maintaining homeostasis to facilitate the understanding of related disease process (C1, C2)
CO2	Describe the gastrointestinal system to understand its contribution to health and diseases (C1, C2)
CO3	Describe the role of renal system in maintenance of homeostasis to facilitate the understanding of related disease processes (C1, C2)
CO4	Explain the physiology of endocrine and reproductive system and its contribution to homeostasis to facilitate the understanding of related disease processes (C1, C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x							
CO4	x							

Course Content and Outcomes:

Topics	Competencies	Number of Hours
Unit 1: Central nervous System		
General organization of nervous system	<ul style="list-style-type: none"> Outline the organization of nervous system (C1) Outline the organization of autonomic nervous system (ANS) (C1) Enumerate the functions of ANS (C1) Mention the functional areas of cerebral cortex and their functions (C1) 	1

Topics	Competencies	Number of Hours
Receptors	<ul style="list-style-type: none"> Classify sensory receptors according to type and location of stimulus, giving examples for each (C2) Explain the property of 'specificity' and 'adequate stimulus' (C2) Explain the property of 'adaptation' of sensory receptors (C2) 	1
Synapse	<ul style="list-style-type: none"> Define 'synapse' (C1) Describe the structure of a synapse (C2) Explain the events in synaptic transmission (C2) 	1
Reflexes	<ul style="list-style-type: none"> Define reflex (C1) Enumerate the components of a reflex arc with the help of a diagram (C1) Describe the stretch reflex with the help of a diagram (C2) Describe withdrawal reflex (C2) Explain the importance of withdrawal reflex (C2) 	2
Ascending pathways	<ul style="list-style-type: none"> Outline the general organization of sensory pathways (C1) Describe the dorsal column and lateral spinothalamic tracts with the help of labelled diagrams (C2) Mention the different sensations that are carried by the above pathways (C1) 	2
Descending pathways	<ul style="list-style-type: none"> Describe the pyramidal/corticospinal tract with the help of a labelled diagram (C2) Tabulate the differences between 'upper motor neuron lesion' and 'lower motor neuron lesion' (C2) 	1
Cerebellum	<ul style="list-style-type: none"> Name the functional divisions of cerebellum (C1) Enumerate the functions of cerebellum (C1) List the clinical features of cerebellar lesion (C1) List the clinical features of cerebellar lesion (C2) 	1
Basal ganglia	<ul style="list-style-type: none"> Mention the components of basal ganglia (C1) Enumerate the functions of basal ganglia (C1) Explain the cause and clinical features of Parkinson's disease (C2) Explain the basis of treatment of Parkinson's disease (C2) 	1
Thalamus and Hypothalamus	<ul style="list-style-type: none"> Mention the functions of thalamus (C1) Explain the functions of hypothalamus (C2) 	2
Cerebrospinal fluid	<ul style="list-style-type: none"> Describe the formation, circulation, absorption and functions of CSF (C2) Mention the method of collection of a sample of CSF and its indications (C1) 	1

Topics	Competencies	Number of Hours
Unit 2: Gastrointestinal system		
Salivary secretion	<ul style="list-style-type: none"> Mention the composition of saliva (C1) 	1
& Deglutition	<ul style="list-style-type: none"> Explain the functions of saliva (C2) Describe the regulation of salivary secretion (C2) Describe the effects of Xerostomia (C2) Define deglutition (C1) Explain the stages of deglutition (C2) Describe dysphagia (C2) Describe Achalasia cardia (C2) 	
Stomach	<ul style="list-style-type: none"> Describe the functions of stomach (C2) Mention the composition of gastric juice (C1) Describe functions of gastric juice (C2) Describe the mechanism of secretion of hydrochloric acid (C2) Describe the regulation of gastric juice secretion (cephalic, gastric and intestinal phases) (C2) 	1
Exocrine portion of Pancreas; Liver and biliary system	<ul style="list-style-type: none"> Outline the composition of pancreatic juice (C1) Describe the functions of pancreatic juice (C2) Describe the neural and hormonal regulation of pancreatic juice (C2) Outline the composition of hepatic bile (C1) Describe the functions of bile (C2) Enumerate the functions of gall bladder (C1) 	1
Small intestine and large intestine	<ul style="list-style-type: none"> Describe the composition and functions of small intestinal secretions (C2) Explain Different types of Intestinal movements and their significance (C2) Explain different types of small intestinal movements (peristalsis and segmentation contractions) and their significance (C2) List the functions of large intestine (C1) 	1
Unit 3: Renal system		
Introduction & Glomerular filtration	<ul style="list-style-type: none"> List the functions of kidneys (C1) Draw a labelled diagram of a nephron (C1) Mention the normal value of renal blood flow (C1) Define glomerular filtration rate (GFR) (C1) Mention the normal value of GFR (C1) Explain the factors influencing GFR (C2) List the substances used for the determination of GFR (C1) 	1
Reabsorption and secretion in renal tubules	<ul style="list-style-type: none"> Describe tubular reabsorption of sodium, glucose and water (C2) 	1

Topics	Competencies	Number of Hours
	<ul style="list-style-type: none"> Define tubular load, renal threshold and tubular/transport maximum (C1) Mention the normal values for tubular load, renal threshold and tubular/transport maximum of glucose (C1) 	
Mechanism of concentration/dilution of urine	<ul style="list-style-type: none"> Describe the role of counter current multiplier and counter current exchanger in the formation of urine (C2) 	1
Physiology of micturition	<ul style="list-style-type: none"> Describe the nerve supply to urinary bladder (C2) Describe the micturition reflex (C2) List the functions of skin 	1
Unit 4: General principles of endocrinology		
Introduction and Pituitary gland	<ul style="list-style-type: none"> Name the major endocrine glands and their secretions(C1) List the anterior pituitary hormones (C1) Describe the actions of growth hormone (C2) Describe the regulation of secretion of growth hormone(C2) Describe the cause and clinical features of gigantism (C2) Describe the cause and clinical features of acromegaly (C2) Describe the cause and clinical features of dwarfism (C2) List the hormones of posterior pituitary (C1) Describe the actions of posterior pituitary hormones (C2) Describe diabetes insipidus (C2) 	1
Thyroid gland	<ul style="list-style-type: none"> List the hormones of thyroid gland (C1) Describe the actions of thyroid hormones(C2) Describe the regulation of secretion of thyroid hormones (C2) Describe the cause and clinical features of hyperthyroidism (C2) Describe the cause and clinical features of cretinism (C2) Describe the cause and clinical features of myxedema(C2) 	2
Adrenal cortex & Adrenal medulla	<ul style="list-style-type: none"> Explain the actions of glucocorticoids (C2) Describe the regulation of secretion of glucocorticoids (C2) Explain the cause and clinical features of Cushing's syndrome (C2) Describe the actions of mineralocorticoids (C2) 	1

Topics	Competencies	Number of Hours
	<ul style="list-style-type: none"> Describe the cause and clinical features of Addison's disease (C2) List the hormones of adrenal medulla (C1) Mention the actions of adrenal medullary hormones (C1) 	
Parathyroid gland	<ul style="list-style-type: none"> Describe the actions of PTH (C2) Describe the regulation of secretion of PTH (C2) Describe the effects of h hypoparathyroidism (C2) 	1
Endocrine Pancreas	<ul style="list-style-type: none"> Describe the actions of insulin (C2) 	1
	<ul style="list-style-type: none"> Describe the cause and clinical features of diabetes mellitus (C2) List the actions of glucagon (C1) 	
Unit 5: Reproductive system		
Male Reproductive system	<ul style="list-style-type: none"> Describe the organization of male reproductive system(C2) Describe the structure and functions of testes (C2) Define spermatogenesis (C1) Describe the stages of spermatogenesis (C2) Mention the actions of testosterone (C1) Describe the regulation of secretion of testosterone (C2) 	1
Female Reproductive system	<ul style="list-style-type: none"> Describe the structure of female reproductive system(C2) Explain the actions of Estrogen and Progesterone (C2) Describe the ovarian changes during menstrual cycle(C2) Describe the uterine endometrial changes during menstrual cycle (C2) Explain the hormonal control of ovarian functions (C2) Mention the indicators of ovulation (C1) 	2
Pregnancy and Lactation; Contraceptive methods	<ul style="list-style-type: none"> Enumerate the functions of placenta (C1) Describe milk ejection reflex (C2) Mention various contraceptive methods in males (C1) Mention various contraceptive methods in females (C1) Explain the mechanism of action of various contraceptive methods (C2) 	1

Learning Strategies, Contact Hours and Out of class engagement				
Learning Strategies	Contact Hours		Out of class engagement)	
Lecture	31		31	
Revision	4		4	
Total	35		35	
Assessment Methods:				
Formative:		Summative:		
Nil		Sessional Exam I / Sessional Exam II (Theory)		
		End Semester Exam (Theory)		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Sessional Examination 1	x	x	-	-
Sessional Examination 2	-	-	x	x
End Semester Exam	x	x	x	x
FeedbackProcess:		End-Semester Feedback		
Main Reference:		1. Basics of Medical Physiology- 4 th Edition by D Venkatesh andHH Sudhaker		

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Biochemistry
Course Code	BIC1401
Academic Year	First
Semester	II
Number of Credits	3
Course Prerequisite	Basic knowledge of Biology and Chemistry
Course Synopsis	Biochemistry broadly deals with the chemistry of life and living processes. It helps in understanding the building blocks—proteins, carbohydrates, fats, nucleic acids and is necessary for allied health professions students to understand various biochemical mechanisms so as to correlate with or identify the pathological processes. Knowledge of biomolecules is necessary to understand the various laboratory investigations and their relevance in clinical practice

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain the classification, composition and functions of macromolecules (C2)
CO2	Describe the process of digestion, absorption and metabolism of carbohydrates and lipids (C2)
CO3	Explain protein digestion and amino acid metabolism, general concepts of nutrition, balanced diet, role of macronutrients in the maintenance of health and features of malnutrition (C2)
CO4	Explain the role of micronutrients in maintenance of health and summarize the features and investigations in diabetes mellitus and acid-base disorders (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x							
CO4	x							

Course Content and Outcomes:

Unit	Content	Competencies	Number of Hours
Unit 1: ENZYMES			
	At the end of this chapter, a student should be able to 1. Define the term 'enzyme' (C1) 2. Classify enzymes based on reaction specificity(IUBMB classification)(C2)		2

Unit	Content	Competencies	Number of Hours
	3. Give one example(names of enzymes & reaction catalyzed)for each class of enzymes(C1) 4. Define the term'isoenzymes' (C1) 5. Explain isoenzymes with examples(creatine kinase, lactate dehydrogenase) (C2) 6. Define the term'proenzyme or zymogen'with pepsinogen and trypsinogen as examples(C1) 7. Describe the utility of serum enzymes as diagnostic markers(C2) 8. Mention the diagnostic utility of following enzymes(C1) <ul style="list-style-type: none"> • CK • ALP • AST • ALT • LDH 		
Unit 2: CARBOHYDRATE CHEMISTRY			
	At the end of this chapter, a student should be able to 1. Define the term'carbohydrates' (C1) 2. Classify carbohydrates with examples for each class(C2) 3. Classify monosaccharides with examples based on(C2) <ul style="list-style-type: none"> • Number of carbon atoms • Functional groups 4. Mention the source and composition of following disaccharides(C1) <ul style="list-style-type: none"> • Sucrose • Lactose • Maltose 5. Classify polysaccharides based on composition with examples(C2) 6. Explain the structure of starch and glycogen with schematic representation(C2) 7. List the differences between starch and glycogen(C1) 8. Mention the occurrence and functions of heparin and chondroitin sulphate(C1)		2
Unit 3: CARBOHYDRATE DIGESTION AND ABSORPTION			
	At the end of this chapter, a student should be able to 1. Describe the complete digestion of dietary polysaccharides(starch and glycogen) (C2) 2. Describe the reactions catalyzed by the following brush border enzymes(C2) <ul style="list-style-type: none"> • Maltase • Sucrase-isomaltase • Lactase 3. Illustrate the mechanisms of absorption of monosaccharides in the small intestine(C2) 4. Explain the significance of including sodium chloride along with glucose in the oral rehydration solution (C2)		2

Unit	Content	Competencies	Number of Hours
Unit 4: CARBOHYDRATE METABOLISM			
	A. Glycolysis At the end of this chapter, a student should be able to 1. Define aerobic and anaerobic glycolysis(C1) 2. Mention the site and subcellular site of glycolysis(C1) 3. Describe the steps of glycolysis with all the enzymes and coenzymes at each step(C2) 4. Mention the regulatory enzymes and list the names of hormones that regulate it in the well-fed state and starvation(C1) 5. Calculate the energetics of aerobic and anaerobic glycolysis (C2)		2
	B. Gluconeogenesis At the end of this chapter, a student should be able to 1. Define gluconeogenesis(C1) 2. Mention the sites & subcellular sites of gluconeogenesis(C1) 3. List the precursors for gluconeogenesis(C1) 4. List the key enzymes of gluconeogenesis(C1) 5. Describe the synthesis of glucose from pyruvate and lactate(C2) 6. Mention the regulatory enzymes and list the names of hormones that regulate it in the well-fed state and starvation(C1) 7. Explain the significance of gluconeogenesis (C2)		2
	C. Citric acid cycle At the end of this chapter, a student should be able to 1. Recall the reaction catalyzed by pyruvate dehydrogenase complex and mention its coenzymes(C1) 2. Mention the site and subcellular site of citric acid cycle(C1) 3. Describe the reactions of citric acid cycle with all enzymes and coenzymes(C2) 4. Mention the regulatory enzymes of citric acid cycle(C1) 5. Calculate the energetics of citric acid cycle(C2)		2
	D. Glycogen metabolism At the end of this chapter, a student should be able to 1. Mention the function of glycogen in liver and muscle(C1) 2. Define glycogenesis & glycogenolysis(C1) 3. Mention the site and subcellular site of glycogen metabolism(C1) 4. Mention the fate of end products of glycogenolysis in liver(role of glucose 6-phosphatase)and muscle(C1) 5. Mention the regulatory enzymes and the hormones involved in regulation in well-fed state and starvation(C1) 6. List the glycogen storage disorders mentioning their names, defects and tissues affected(Type I, V & VI) (C1)		1
Unit 5: ELECTRON TRANSPORT CHAIN AND OXIDATIVE PHOSPHORYLATION			
	At the end of this chapter, a student should be able to 1. Define the electron transport chain(ETC) (C1) 2. Name the subcellular site of ETC(C1)		1

Unit	Content	Competencies	Number of Hours
	3. Describe the complexes of ETC(with their components and order of arrangement)and mention the mobile electron carriers(C2) 4. Name the inhibitors for each of the complexes of ETC(C1) 5. Define oxidative phosphorylation (C1)		
Unit 6: LIPID CHEMISTRY			
	At the end of this chapter, a student should be able to 1. Define lipids(C1) 2. Explain the functions of lipids in the body(C2) 3. Classify lipids with examples for all the subclasses(C2) 4. Classify fatty acids with examples-saturated, unsaturated(based on number of double bonds), essential fatty acids (C2)		1
Unit 7: LIPID DIGESTION, ABSORPTION AND ASSOCIATED DISORDERS			
	At the end of this chapter, a student should be able to 1. Explain the process of emulsification of lipids(C2) 2. Describe the digestion of lipids in the stomach and intestine(C2) 3. Illustrate the process of absorption of lipids(C2) 4. Define steatorrhea and list its causes (C1)		2
Unit 8: LIPID METABOLISM			
	A. De novo synthesis of fatty acids At the end of this chapter, students should be able to 1. Mention the site and subcellular site of de novo synthesis of fatty acids(C1) 2. List the sources of acetyl CoA for de novo synthesis of fatty acids(C1) 3. Explain the reaction catalyzed by acetyl CoA carboxylase(C2) 4. Mention the regulatory enzyme and the hormones involved in regulation in well-fed state and starvation(C1)		1
	B. Synthesis of triacylglycerol(TAG) At the end of this chapter, students should be able to 1. Show the schematic structure of triacylglycerol(C1) 2. Mention the site and subcellular site of TAG synthesis(C1) 3. Describe the reactions of TAG synthesis(C2) 4. Mention the fate of TAG in liver and adipose tissue (C1)		1
	C. Lipolysis At the end of this chapter, students should be able to 1. Mention the site and subcellular site of lipolysis(C1) 2. Describe the reactions of lipolysis(C2) 3. Mention the regulatory enzymes and the hormones involved in regulation in well-fed state and starvation (C1)		1
	D. Beta oxidation of fatty acids At the end of this chapter, students should be able to 1. Define beta-oxidation(C1) 2. List the site and subcellular site of beta-oxidation(C1) 3. Describe the activation of palmitic acid(C2) 4. Explain the transport of activated palmitic acid into		2

Unit	Content	Competencies	Number of Hours
	mitochondria(carnitine shuttle) (C2) 5. Describe the reactions of beta oxidation(C2) 6. Calculate the energetics of beta oxidation of palmitic acid (C2)		
E. Lipoproteins	At the end of this chapter, student should be able to 1. Classify lipoproteins based on their electrophoretic mobility and ultracentrifugation properties(C2) 2. Mention the site of synthesis and the functions of Chylomicrons, VLDL, LDL and HDL (C1)		1
Unit 9: AMINO ACID & PROTEIN CHEMISTRY			
	At the end of this chapter, student should be able to 1. Recognize the general structure of D and L amino acids(C1) 2. Classify amino acids based on the following with examples(C2) <ul style="list-style-type: none"> • Presence in proteins(standard and non-standard amino acids) • Metabolic fate(glucogenic and ketogenic amino acids) • Nutritional requirement(essential and non-essential amino acids) 3. Classify proteins based on composition, functions and shape with examples(C2) 4. Describe the structure of mature collagen with diagram(C2) 5. Explain with illustrations the biosynthesis of mature collagen emphasizing the importance of prolyl hydroxylase, lysyl hydroxylase and lysyl oxidase (C2)		3
Unit 10: PROTEIN DIGESTION AND ABSORPTION			
	At the end of the chapter, a student should be able to 1. Outline the activation of zymogens in the GIT(C1) 2. List the endo and exopeptidases in the digestive juices(C1)		1
Unit 11: AMINO ACID METABOLISM			
	At the end of the chapter, a student should be able to 1. Explain transamination of amino acids with suitable examples(C2) 2. Describe the generation of ammonia by oxidative deamination using L- glutamate dehydrogenase. (C2) 3. Study urea cycle as follows <ul style="list-style-type: none"> • Name its site and subcellular site(C1) • Describe its reactions(C2) • Mention its significance(C1) 4. Recall the physiologically important products derived from the following amino acids(C1) <ul style="list-style-type: none"> • Glycine • Tyrosine • Methionine • Tryptophan 		2
Unit 12: GENERAL CONCEPTS OF NUTRITION			
	At the end of the chapter, a student should be able to 1. Define the term balanced diet(C1) 2. Define caloric value of food and list the caloric values of		2

Unit	Content	Competencies	Number of Hours
	<p>carbohydrates, proteins and fats(C1)</p> <ol style="list-style-type: none"> State the total daily caloric requirements of an adult male and female(for sedentary, moderate and heavy workers)and for pregnant and lactating women(C1) Define recommended dietary allowance(RDA) (C1) Study basal metabolic rate as follows <ul style="list-style-type: none"> Define(C1) List the normal values for men and women(C1) Explain the factors affecting BMR(C2) Define thermic effect(SDA)of food and recall the values for macronutrients (C1) 		
Unit 13: CARBOHYDRATES, PROTEINS AND FATS IN NUTRITION			
	<p>A. Carbohydrates</p> <p>At the end of the chapter, a student should be able to</p> <ol style="list-style-type: none"> Mention the RDA(C1) Study dietary fibers as follows <ul style="list-style-type: none"> Define(C1) Mention its RDA(C1) List the examples with their sources(C1) Explain its beneficial effects(C2) <p>B. Proteins</p> <p>At the end of the chapter, a student should be able to</p> <ol style="list-style-type: none"> Mention the RDA(C1) Define essential amino acids with examples (C1) Study biological value as follows <ul style="list-style-type: none"> Define(C1) Name the protein used as standard for determining it(C1) List the protein sources with high and low biologic values(egg albumin, milk, fish, meat, rice, wheat and soy protein) (C1) Define the term nitrogen balance(C1) Explain positive and negative nitrogen balance with conditions during which they occur(C2) Define the term limiting amino acids giving suitable examples(C1) Explain mutual supplementation of proteins with examples(C2) <p>C.FATS</p> <p>At the end of the chapter, a student should be able to</p> <ol style="list-style-type: none"> Mention the RDA(C1) List the functions of cholesterol in the body(C1) Study essential fatty acids as follows <ul style="list-style-type: none"> Define(C1) Mention its RDA(C1) Explain their functions and deficiency manifestations(C2) Explain saturated and unsaturated(mono and poly)fatty acids with suitable examples, mentioning its sources and functions (C2) 		2

Unit	Content	Competencies	Number of Hours
Unit 14: MINERALS			
	At the end of this chapter, a student should be able to 1. Define the terms macro and micro minerals with examples. (C1) 2. Mention the sources and RDA for iron(C1) 3. Explain the functions, disorders of deficiency & excess for iron(C2) 4. Mention the sources, RDA and functions for calcium and phosphorus(C1) 5. Mention the normal serum levels of calcium and phosphorus and the hormones which regulate it (C1)		2
Unit 15: VITAMINS			
	At the end of this chapter, a student should be able to 1. Define the term vitamins(C1) 2. List the classes of vitamins based on solubility(C1) 3. Study the water soluble vitamins mentioned below <ul style="list-style-type: none"> • Thiamine • Riboflavin • Niacin • Pantothenic acid • Pyridoxine • Biotin • Cobalamin • Folic acid • Ascorbic acid as follows • List the RDA, sources and coenzyme forms(C1) • Describe the biochemical functions(C2) • List the features of disorders associated with their deficiencies(C1) 4. Study the fat soluble vitamins A, D, E, K as follows <ul style="list-style-type: none"> • List the RDA, sources and chemical forms. (C1) • Describe the biochemical functions. (C2) • List the features of disorders associated with their deficiencies and excess. (C1) 		3
16. MALNUTRITION			
	At the end of this chapter, a student should be able to 1. Define the classes of protein energy malnutrition. (C1) 2. Compare the similarities and differences between marasmus and kwashiorkor (C2)		1
17. CLINICAL BIOCHEMISTRY			
	A. GLUCOSE HOMEOSTASIS AND DIABETES MELLITUS At the end of this chapter, a student should be able to 1. Summarize the effect of the hormones involved in blood glucose homeostasis(C2) 2. Study diabetes mellitus as follows <ul style="list-style-type: none"> • Define(C1) 		2

Unit	Content	Competencies	Number of Hours
	<ul style="list-style-type: none"> Classify and compare the types 1 and 2(C2) Mention the signs and symptoms(C1) Mention the normal plasma levels of fasting, postprandial and random glucose & their utility in diagnosis(C1) Explain the relevant investigations involved in the diagnosis and management(HbA_{1c}, procedure and interpretation of GTT, microalbuminuria) (C2) Explain the biochemical basis for features of diabetic ketoacidosis(C2) 		
	<p>B. SIGNIFICANCE OF ESTIMATIONS OF VARIOUS BIOCHEMICAL PARAMETERS IN BLOOD</p> <p>At the end of this chapter, a student should be able to</p> <p>1.Mention the normal serum levels of glucose, protein, urea, uric acid, bilirubin, cholesterol and creatinine and conditions in which they are altered(C1)</p>		1
	<p>C. ACID BASE BALANCE AND DISTURBANCES</p> <p>At the end of this chapter, a student should be able to:</p> <p>1. Define the terms acid, base, pH and pKa(C1)</p> <p>2. Study buffers as follows</p> <ul style="list-style-type: none"> Define(C1) Write the Henderson-Hasselbalch equation for different buffer systems(C1) List the principal buffer systems in ECF, ICF and in urine(C1) Mention the pKa value, normal ratio of base/acid in the plasma for bicarbonate and phosphate buffer systems(C1) <p>3. Study acid-base disorders as follows</p> <ul style="list-style-type: none"> Define the different classes(C1) Explain the conditions causing acidosis & alkalosis(metabolic & respiratory) (C2) <p>4. Mention the primary and compensatory changes in acid base disorders (C1)</p>		1
Unit 18: MOLECULAR BIOLOGY			
	<p>At the end of this chapter, a student should be able to</p> <p>1. Name the purine and pyrimidine bases(C1)</p> <p>2. Define nucleosides and nucleotides with examples(C1)</p> <p>3. Illustrate the Watson and Crick model of B-DNA structure(C2)</p> <p>4. List the different types of RNA(C1)</p> <p>5. Recall the structural differences between DNA and RNA(C1)</p> <p>6. Define re plication, transcription and translation (C1)</p>		2

Learning Strategies, Contact Hours and Out of class engagement				
Learning Strategies	Contact Hours		Out of class engagement	
Lecture	45		45	
Assessment	4		4	
Total	49		49	
Assessment Methods:				
Formative:		Summative:		
Nil		Sessional Exam I / Sessional Exam II (Theory)		
		End Semester Exam (Theory)		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Sessional Examination 1	x	x	-	-
Sessional Examination 2	-	-	x	x
End Semester Exam	x	x	x	x
Feedback Process:	End Semester Feedback			
Main Reference:	1. Essentials of Biochemistry, U satyanarayana, U Chakrapani (2 nd edition) 2. Handbook of Biochemistry for Allied & Nursing Students, Shivananda Nayak B (2 nd edition)			

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Environmental Science
Course Code	EIC1501
Academic Year	First
Semester	I
Number of Credits	1
Course Prerequisite	Nil
Course Synopsis	1. Aim to give students a general understanding of environmental science and introduce them to some of the main principles 2. It covers the study of subjects for example, understanding of earth procedures, evaluating alternative energy frameworks, mitigation and pollution control, natural resource management, effects of global climate change, and so on

Course Outcomes (COs):
At the end of the course students shall be able to:

CO1	Explain the role of Environmental Science, its multidisciplinary nature in conservation of global environment (C2)
CO2	Describe the natural resources, utility and the role of ecosystems in maintaining planetary cycles (C2)
CO3	Outline the types, sources, prevention and control measures of pollution (C2)
CO4	List the laws, acts and policies related to environmental protection in India (C1)
CO5	Explain the types, mitigation and management techniques of disaster (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x					x		
CO2	x			x				
CO3	x					x		
CO4			x				x	
CO5			x			x		

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Environmental Studies and multi-disciplinary nature	1. Explain the meaning, objectives and major environmental issues (C2) 2. What is sustainable development? (C1)	2

Content	Competencies	Number of Hours
	3. Explain the global environmental concerns (C2)	
Unit 2		
Biodiversity, Ecosystem, Energy and natural resources	<ol style="list-style-type: none"> 1. Classify the natural resources (C2) 2. List the renewable and non-renewable resources (C1) 3. Outline the consumption of renewable and non-renewable resources 4. Explain the conservation methods of renewable and non-renewable resources 5. Outline the availability of water resources, forest, land and mineral resources. 6. Summarize the different types of energy (C2) (Conventional sources & Non-Conventional sources of energy, solar energy, Hydro electric energy, Wind Energy, Nuclear energy, Biomass & Biogas, Fossil Fuels, Hydrogen as an alternative energy) 7. Define Ecosystem (C1) 8. Explain the meaning, structure and functions of ecosystem (C2) 9. Explain the biotic and abiotic components of ecosystem (C2) 10. Describe the trophic levels in ecosystem (C2) 11. What is an energy flow in an ecosystem (C1) 12. Explain Biodiversity and its conservation (C2) (in situ & ex situ, IUCN red list) 	4
Unit 3		
Environmental Pollution	1. Explain the various types of Environmental Pollution (C2) (water, air, land, noise, solid waste, Biomedical waste, nuclear pollution, marine pollution)	2
Unit 4		
Environmental laws and legislations	<ol style="list-style-type: none"> 1. Outline the environmental laws and legislations (C2) (Related to general, air, water, biodiversity and forests) 2. Explain the roles and responsibilities of state and central Pollution control Boards (C2) 3. What is Environmental impact assessment (EIA) (C1) 	2
Unit 5		
Disaster management	<ol style="list-style-type: none"> 1. Define disaster (C1) 2. What is disaster management? (C1) 3. Classify the types of disaster (C2) 4. What is disaster risk formula (C1) 5. Explain the phases in 	3

Content	Competencies	Number of Hours
	Disaster management phases (C2) (Disaster management cycle, Emergency response and recovery, Hazardous waste spills and dangers posed)	

Learning Strategies, Contact Hours and out of class engagement:					
Learning Strategies	Contact Hours	Out of class engagement			
Lecture	13	13			
Assessment	2	2			
Total	15	15			
Assessment Methods:					
Formative:			Summative:		
Assignments			Mid Semester/Sessional Exam (Theory)		
Mapping of Assessment with COs:					
Nature of Assessment	CO1	CO2	CO3	CO4	CO5
Class test	-	-	X	X	X
Mid Semester / Sessional Examination	X	X	X	-	-
Feedback Process:	End-Semester Feedback				
Main Reference:	1. Benny Joseph, Environmental Studies, Tata McGraw-Hill Publishing Company Ltd., New Delhi (2008). 2. Aloka Debi, "Environmental Science and Engineering", Universities Press (India) Pvt. Ltd. (2012).				
Additional References	1. Mohan kanda, Disaster Management in India evolution of institutional arrangements & operational strategies. (2017) 2. Student guide: Environment Reader for Universities, based on UGC syllabus published by Centre for Science and Environment, (2017). 3. G.Swarajya Lakshmi, Environmental science: A Practical Manual, (2010).				

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Indian Constitution
Course Code	EIC1501
Academic Year	First
Semester	II
Number of Credits	1
Course Prerequisite	Nil
Course Synopsis	1. To provide understanding of knowledge of the Indian constitution. 2. To familiarize students with the fundamental rights and duties. 3. To understand the importance of constitutional laws. 4. To understand the correlation between Indian constitution, democracy and society.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain the salient features, importance and need of the Constitution (C2)
CO2	Infer the need of fundamental rights in a democratic system for a holistic development of a society (C2)
CO3	Outline the directions given to the state by the constitution and fundamental duties of a citizen towards the state. (C2)
CO4	Explain the working nature of State and Centre, roles and responsibilities of President and Governors, amendments emergency powers enjoyed by the government (C2)
CO5	List various laws listed under IPC and CrPC and understand importance of voting in a democracy and RTI (C1)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2				x	x			
CO3			x				x	
CO4						x		x
CO5				x			x	

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Introduction to Indian Constitution	1. Outline the evolution of the Legal System (C1) (pre-colonial and colonial times, Common Law, Civil Law and Socialist Legal System)	3

Content	Competencies	Number of Hours
	2. Explain the constitutional history and constitutional assembly (C2) 3. Explain the various organs of the Government (C2) (Executive, Legislature and Judiciary, and Panchayat institutions) 4. Summarise the functions of high court and supreme court of India (C2)	
Unit 2		
Fundamental Rights	1. Explain the individual rights and fundamental rights (C2) 2. Outline the history of the demand for fundamental rights (C2) 3. Classify the fundamental rights (C2) 4. Explain how fundamental rights are a guarantee against state action (C2) 5. Summarise Article 14 to Article 30 (C2) 6. Explain supreme court as the guardian of Fundamental Rights (C2)	4
Unit 3		
Fundamental Duties and Directive Principles of State Policy	1. Explain fundamental duties and its enforcement (C2) 2. Summarise the utility and the scope of DPSP(C2) 3. Outline the socialistic pattern of society (C2) 4. Explain the conflict between fundamental rights and DPSP (C2)	3
Unit 4		
Role of President and Governors/ Cabinet	1. What is the procedure followed while electing a President (C1) 2. Explain the power and duties of the President (C2) 3. Outline the power and duties of the Governors (C2) 4. Explain the role and functions of the council of Ministers (C2)	2
Unit 5		
Role of citizens, Constitutional laws(IPC and CrPC), RTI	1. Explain the role of citizens in a democracy (C2) 2. Explain constitutional laws (C2) 3. Explain the Indian Penal Code and Code of Criminal Procedure (C2) 4. Summarise right to Information (C2)	3

Learning Strategies, Contact Hours and out of class engagement :					
Learning Strategies	Contact Hours	Out of class engagement			
Lecture	15	15			
Total	15	15			
Assessment Methods:					
Formative:			Summative:		
Assignments			Mid Semester/Sessional Exam (Theory)		
Mapping of Assessment with COs:					
Nature of Assessment	CO1	CO2	CO3	CO4	CO5
Class test	-	x	-	x	x
Mid Semester / Sessional Examination	x	x	x	-	-
Feedback Process:	End-Semester Feedback				
Main Reference:	1. Subhash C. Kashyap, Our Constitution, National Book Trust. (2011) 2. P. M. Bhakshi. The Constitution of India. Universal Law Publishing.(2017)				
Additional References	1. Dr. B. R. Ambedkar. The Constitution of India. Educreation Publishing. (2020) 2. Bipan Chandra. History of Modern India. Orient BlackSwan. (2009) 3. Dr. Durga Das Basu. Introduction to the Constitution of India. Lexis Nexis.(2013)				

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Communication Skills							
Course Code	CSK1501							
Academic Year	First							
Semester	II							
Number of Credits	2							
Course Prerequisite	Nil							
Course Synopsis	Orients students to focus on diverse interactive situations and enhances the interpersonal skills required as per the needs of the current professional environment							
Course Outcomes (COs): At the end of the course student shall be able to								
CO1	Identify the components of communication skills and apply them in a professional setting with an emphasis on professional communication specifically on presentation and corporate etiquette (C3)							
CO2	Outline effective oral communication skills in diverse contexts (C2)							
CO3	Summarise different ways to write creatively, coherently and effectively on a given topic (C2)							
CO4	Develop active listening skills involving feedback in diverse interactive situations. (C3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1					x		x	
CO2					x		x	
CO3		x					x	
CO4			x				x	

Course Content and Outcomes:

Content	Competencies	Number of Hours (Theory)
Unit 1		
Communication Skills	1. Define Communication (C1) 2. Outline the process and barriers in Communication (C2) 3. Explain the types of communication (C2) (Oral, Verbal, non-verbal, dyadic) 4. How to improve spoken skills (C1)(Telephone, face-to-face) 5. How to improve communication (C1) 6. Apply the concepts of communication skills in a professional setting with an emphasis on	8

Content	Competencies	Number of Hours (Theory)
	presentation and corporate etiquette (C3) 7. Identify the difference between formal and informal communication (C3)	
Unit 2		
Reading Skills	<ol style="list-style-type: none"> 1. Explain the types of reading (C2) 1. (Oral, Silent, Extensive, Scanning, Skimming) 2. Outline the reading techniques (C2) (3Q3R) 3. What is the difference between scanning and skimming(C1) 4. Define source of information (C1) 5. Explain feedback on LSWR in individual presentations (C2) 6. Summarise the role played by prepositions in understanding what to read (C2) 	6
Unit 3		
Listening Skills	<ol style="list-style-type: none"> 1. Explain the types of listening (C2) 2. Summarize the context and purpose of listening (C2) 3. Explain various types of listening obstacles (C2) 4. How to improve hearing and focused listening (C1) 5. 5. What is facilitating understanding, static & process description-gambits (C1) 	8
Unit 4		
Writing skills	<ol style="list-style-type: none"> 1. What is the difference between spoken and written form (C1) 2. How words are formed into phrases & clauses (C1) 3. Outline writing paragraphs, cohesion, and coherence (C2) 4. Explain summary, precise and essay writing (C2) 5. How to write a formal and informal letters (C1) 6. How to write a resume /CV(C1) 7. Explain the role of visual aids and meetings in writing (C2) 8. Explain the importance of abbreviations and punctuations in writing(C2) 	8

Learning Strategies, Contact Hours and Out of class engagement		
Learning Strategies	Contact Hours	Out of class engagement
Lecture	24	24
Seminar	6	6
Total	30	30

Learning Assessment Methods:				
Formative:		Summative:		
Class Presentation/Assignment		Sessional Exam II (Theory)		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Assignments	x	x	x	-
Mid Semester Examination	x	x	x	x
Feedback Process:	End-Semester Feedback			
Main Reference:	<ol style="list-style-type: none"> 1. Jain, A K & et al., (2008-5th Edition). Professional Communication Skills, 2008, New Delhi, S Chand and Company 2. Raman, M., & Singh, P. (2012). Business communication. New Delhi: Oxford University Press 3. The Professional Communications Toolkit by D. Joel Whalen Sage publication 2006. 			
Additional References	<ol style="list-style-type: none"> 1. Raman, M & Sharma, S (2014). Technical communication: Principles and Practice. New Delhi: Oxford University 			

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Cell and Molecular Biology						
Course Code		NMT1401						
Academic Year		First						
Semester		II						
Number of Credits		4						
Course Prerequisite		Basic knowledge of Biology						
Course Synopsis		This module provides fundamental knowledge of cell physiology						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	List and classify various cellular macromolecules. (C2)							
CO2	Explain function and organization of cellular organelles (C2)							
CO3	Understand basic structure and characteristics of DNA and RNA (C2)							
CO4	Understand DNA replication, transcription, and translation processes (C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x							
CO4	x							

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Plasma membrane and Nucleus	1. List theories of origin of life (C1) 2. Explain theories on molecular architecture of plasma membrane. Explain structure of plasma membrane and Outline chemical composition of plasma membrane(C2) 3. Explain transport of molecules-active and passive (C2) 4. Explain role of ion channels in cellular transport (C2) 5. Illustrate cell-cell interaction (C2)	05
	1. Demonstrate organization of Nucleus and chromosomes 2. Illustrate structure and function of nuclear Envelope and nuclear pore complex (C2) 3. Explain selective transport of proteins across	06

Content	Competencies	Number of Hours
	<ul style="list-style-type: none"> nuclear pore (Import) (C2) 4. Explain selective transport of proteins across nuclear pore (Export) (C2) 5. Explain Internal organization of nucleus, chromosomes and chromatin structure (C2) 6. Explain structure and function of nucleolus (C2) 	
Bioenergetics and Metabolism	<ul style="list-style-type: none"> 1. Demonstrate structure and function of mitochondria (C2) 2. Explain Krebs cycle (C2) 3. Explain electron transport chain (C2) 4. Explain protein import into the mitochondria (C2) 5. Explain transport of metabolites across inner mitochondrial membrane (C2) 	05
	<ul style="list-style-type: none"> 1. List functions of peroxisomes (C1) 2. Demonstrate peroxisomal assembly and biochemical characterization (C2) 3. Explain glyoxylate cycle (C2) 4. Explain Photorespiration (C2) 	04
Unit 2		
Protein sorting and Transport	<ul style="list-style-type: none"> 1. Define endoplasmic reticulum, golgi apparatus and lysosomes (C1) 2. Explain general organization of endoplasmic reticulum and targeting of proteins to endoplasmic reticulum (C2) 3. Explain Insertion of proteins into endoplasmic reticulum membrane (C2) 4. Explain Quality control in Endoplasmic reticulum (C2) 5. List functions of smooth endoplasmic reticulum (C1) 6. Explain role of Smooth endoplasmic reticulum in lipid synthesis (C2) 7. Demonstrate organization of Golgi apparatus (C2) 8. Explain protein sorting and export from Golgi apparatus (C2). 9. Explain lysosome formation (C2) 	08
Cell signalling	<ul style="list-style-type: none"> 1. List modes of cell-cell signalling (C1) 2. Explain G Protein-coupled receptor, receptor Protein-Tyrosine kinases and cytokine receptors organisation (C2) 3. Enlist intracellular signal transduction pathways (C1) 4. Explain cAMP pathway, cyclic GMP, Phospholipids, Ca²⁺ PI-3Kinase/Akt, mTOR and MAP kinase pathways 	6

Content	Competencies	Number of Hours
Unit 3		
DNA structure and DNA replication	1. Enlist different types of DNA (A, B and Z DNA) (C1) 2. Understand DNA helix structures and function of Restriction endonucleases (C2) 3. Explain function of DNA ligases, topoisomerases and gyrase (C2) 4. Explain supercoiling of DNA 5. Explain semiconservative and semi-discontinuous nature of DNA synthesis (C2) 6. Explain structure, components and function of DNA polymerase (C2) 7. Explain process of DNA synthesis (C2)	13
RNA synthesis & Processing	1. List major types of RNA (C1) 2. Illustrate structure and function of RNA polymerase, its subunits and general transcription factors (C2) 3. Explain process of RNA synthesis and regulation (C2) 4. Explain RNA processing of ribosomal and transfer RNAs (C2) 5. Explain splicing and alternative splicing mechanisms (C2) 6. Explain RNA editing and degradation (C2)	06
Translation	1. Enlist components of translation (C1) 2. Explain structure of tRNA (C2) 3. amino acid activation, fidelity of aminoacylt RNA synthetases (C2) 4. Explain the process of initiation of protein synthesis (C2) 5. Explain the process of elongation of peptide chain (C2) 6. Explain the process of termination of translation 7. Explain the role of stop codons (C2)	07

Learning Strategies, Contact Hours and Out of class engagement:		
Learning Strategies	Contact Hours	Out of class engagement
Lecture	45	40
Seminar	11	11
Revision	2	4
Assessment	2	5
Total	60	60

Assessment Methods:					
Formative:		Summative:			
Unit Test		Mid Semester Exam (Theory)			
Quiz		End Semester Exam (Theory)			
Assignments/Presentations					
Mapping of Assessment with COs:					
Nature of Assessment		CO1	CO2	CO3	CO4
Mid Semester / Sessional Examination 1		x	x	-	-
Quiz / Viva/ Unit Test		x	x	x	x
Assignments/Presentations		x	x	x	x
End Semester Exam		x	x	x	x
Feedback Process:		Mid-Semester Feedback			
		End-Semester Feedback			
Main Reference:		1. Cell and Molecular Biology by de Robertis and de Robertis Llewellyn Pub 2001			
		2. Molecular Biology of the Cell by Alberts, Bray, Lewis, Raff, Roberts and Watson. Garland Science; 1997			
Additional References		1. The Cell – A Molecular Approach by Geoffrey M.Cooper, ASM Press Washington,DC, Oxford University Press 2000.			
		2. Molecular Cell Biology by Darnell, Lodish, Baltimore, Scientific American Books 1990.			
		2. Genes IX, Benjamin Lewin, Jones and Bartlett; 2008			

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Bioethics and Patient Care							
Course Code	NMT1402							
Academic Year	First							
Semester	II							
Number of Credits	3							
Course Prerequisite	Nil							
Course Synopsis	This module provides information regarding ethical practices in preclinical and clinical research. It will also familiarize students with hospital organization and functioning, use of drugs, and equipment in nuclear medicine							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand principles of bioethics in handling patients (C2)							
CO2	Understand principles of bioethics in preclinical and clinical studies (C2)							
CO3	Understand different hospital procedures for patient safety (C2)							
CO4	Understand the principle of care of patients (C2)							
CO5	Understand application of different drugs available in the department of nuclear medicine (C2)							
CO6	Understand application of different laboratory items and equipment in nuclear medicine laboratory (C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		x		x				
CO2				x	x			
CO3		x		x				
CO4		x		x				
CO5		x			x			
CO6			x		x			

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Medical ethics	1. Outline historical overview of bioethics (C2) 2. Define goal, scope, prayer, oath, covenants, declarations 3. Explain guidelines and basic principles of medical ethics (C2)	3

Content	Competencies	Number of Hours
Organizational Ethics	<ol style="list-style-type: none"> 1. Explain Malpractice and negligence - Rational and irrational drug therapy(C2) 2. Explain the risk benefit analysis, compensation, care of terminally ill patient and euthanasia (C2) 3. What is an informed consent?(C1) 4. Explain autonomy and informed consent - Right of patients (C2) 5. Explain Professional Indemnity insurance policy and development of standardized protocol to avoid near miss or sentinel events (C2) 	6
Medico legal aspects of medical records	<ol style="list-style-type: none"> 1. What is Medico legal case and type- Records and document related to MLC - ownership of medical records? (C1) 2. Explain the confidentiality privilege communication.(C2) 3. Explain release of medical information - Unauthorized disclosure and retention of medical records - other various aspects.(C2) 	4
Unit 2		
Animal Ethics	<ol style="list-style-type: none"> 1. Outline historical overview of animal rights (C2) 2. Explain 3Rs of animal testing (C2) 3. Explain ethical guidelines for animal and clinical research (C2) 	4
Hospital organization and procedure	<ol style="list-style-type: none"> 1. Explain the hospital organization (C2) 2. Explain organization and functioning of nuclear medicine unit/department(C2) 3. Explain maintenance of hospital records and stocks (C3) 4. Explain importance of professional attitude towards patients and other members of the staff (C3) 5. List do's and don't for patient safety during various clinical/diagnostic procedures. (C1) 	8
Care of the patient	<ol style="list-style-type: none"> 1. Demonstrate patient care in Diagnostic Nuclear Medicine (C2) 2. Demonstrate patient care in Therapeutic Nuclear Medicine (C2) 3. Explain patient care and safety at both organisation and department level (C2). 	6
Unit 3		
First aid	<ol style="list-style-type: none"> 1. Define aims and objectives of first aid. (C1) 	4
Drugs in the department	<ol style="list-style-type: none"> 1. Understand the application of different drugs in nuclear medicine (C2) 2. List the emergency drugs in Nuclear medicine (C1). 	3

Content	Competencies	Number of Hours
Acquaintance of equipment	1. Define and explain the the principles of the various radiation/non-radiation equipment/devices available in Nuclear Medicine department (C2) 2. Explain the setting of trays , trolleys and emergency instruments in the Nuclear Medicine patient handling area (C2) 3. Explain the methods of sterilization and use of CSSD (C2)	7

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	30
Seminar	11	11
Revision	2	2
Assessment	2	2
Total	45	45

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester/Sessional Exam (Theory)
Quiz	End Semester Exam (Theory)
Assignments/Presentations	

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester / Sessional Examination 1	x	x	x	-	-	-
Quiz / Viva/ Unit Test	x	x	x	x	x	x
Assignments/Presentations	x	x	x	x	x	x
End Semester Exam	x	x	x	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback
Main Reference:	1. Care of patient in diagnostic Radiography By: Chesney & Chesney. 2. Chesney's Care of the patient in Diagnostic Radiography By: Pauline J Culmer. 3. Aid to Tray and Trolley Setting By: Marjorie Houghton
Additional References	1. Physics in Nuclear Medicine By Sorenson

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Practicum - II							
Course Code	NMT1403							
Academic Year	First							
Semester	II							
Number of Credits	3							
Course Prerequisite	Basic Knowledge of microscope, cell and molecular biology							
Course Synopsis	This module provides fundamental knowledge of handling light microscope, identifying H&E stained tissue sections, estimating DNA and protein content using spectrophotometric method.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	To understand practical aspects of Cell biology(C2,P5)							
CO2	To understand practical aspects of molecular biology (C2,P5)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Cell Biology Practicals	1. To study different part of light microscope and their use (C2) (P1) 2. To observe cheek cells under dark and bright field microscopy (C2) (P1) 3. To Demonstrate the microscopic organization of hepatic tissue using light microscopy (C2) (P1) 4. To Demonstrate the microscopic organization of renal tissue using light microscopy (C2) (P1) 5. To Demonstrate the microscopic organization of cardiac tissue using light microscopy (C2) (P1) 6. To Demonstrate the microscopic organization of skin tissue using light microscopy (C2) (P1) 7. To Demonstrate the microscopic organization of retinal tissue using light microscopy (C2) (P1) 8. To demonstrate total leukocyte counting in blood sample using hemocytometer (C2) (P5) 9. To demonstrate total Red blood cell counting in blood sample using hemocytometer (C2) (P5)	52

Content	Competencies	Number of Hours
	10.To prepare peripheral blood smear slide using wedge technique (C2) (P5) 11.To observe May-Grunewald-Giemsa stained leucocytes under light microscope (C2) (P5) 12.To demonstrate Differential leukocyte counting in a blood sample (C2) (P5) 13.To demonstrate cellular organelle separation using differential centrifugation (C2) (P5)	
Unit 2		
Molecular Biology practicals	1. To demonstrate DNA content measurement using colorimetric method (C2) (P5) 2. To demonstrate protein estimation in a given sample using lowry's method (C2) (P5) 3. To demonstrate osmotic fragility of RBCs(C2) (P5) 4. To demonstrate agarose gel electrophoresis technique for separation of DNA (C2) (P5)	23

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	15	15
Practical	50	50
Revision	5	10
Assessment	5	0
Total	75	75

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester Exam (Practical)
Quiz	End Semester Exam (Theory)
Viva	Viva
Practical Log Book/ Record Book	Record Book

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2
Mid Semester / Sessional Examination 1	x	x
Quiz / Viva/ Unit Test	x	x
Clinical/Practical Log Book/ Record Book	x	x
End Semester Exam	x	x
Feedback Process:	Mid-Semester Feedback	
	End-Semester Feedback	

Main Reference:	1. Cell and Molecular Biology by de Robertis and de Robertis Llewellyn Pub 2001
	2. Molecular Cell Biology by Darnell, Lodish, Baltimore, Scientific American Books 1990
Additional References	1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Clinical Practice							
Course Code	NMT1404							
Academic Year	First							
Semester	II							
Number of Credits	1							
Course Prerequisite	A basic understanding on safe handling of radiations							
Course Synopsis	To understand the basic applications of radiation Physics, electronics, bio ethics & patient care in clinical nuclear medicine practice.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	To understand practical aspects of safely handling of radiopharmaceuticals for clinical applications in Nuclear Medicine (C2, A1)							
CO2	To observe the different imaging and non-imaging Nuclear Medicine procedures.(C2, A1)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2		x	x					

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
	1. To understand the principles and observe the practices in hospital radiopharmacy (C2, A1)	12
	2. To understand the principles and observe the practices in in-vitro Nuclear Medicine (C2, A1)	8
Unit 2		
	1. To understand the principles and observe the practices in SPECT Scintigraphy (C2, A1)	18
	2. To understand the principles and observe the practices in radiation therapy (C2, A1)	7

Learning Strategies, Contact Hours and Out of class engagement		
Learning Strategies	Contact Hours	Out of class engagement
Small group discussion (SGD)	5	5
Problem Based Learning (PBL)	2	2
Case Based Learning (CBL)	12	12
Clinic	26	26
Total	45	45
Assessment Methods:		
Formative:		Summative:
Unit Test		Mid Semester Exam(Practical)
Quiz		Viva
Viva		Record Book
Clinical assessment (OSCE, OSPE, WBPA)		
Clinical/Practical Log Book/ Record Book		
Mapping of Assessment with COs:		
Nature of Assessment	CO1	CO2
Mid Semester Examination	x	x
Quiz / Viva/ Unit Test	x	x
Clinical/Practical Log Book/ Record Book	x	x
Any others: WPBA	x	x
Feedback Process:	Mid-Semester Feedback	
	End-Semester Feedback	
Main Reference:	1. Quality control of Nuclear Medicine instruments - Tecdoc 602 2. Nuclear Medicine – The Requisites by Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall	
Additional References	1. Radiopharmaceuticals in Nuclear Medicine by Kowalsky, Richard J., and Steven W. Falen 2. Radiation safety Nuclear Medicine by AERB Mumbai	

SEMESTER - III

Course code	:	Course Title
NMT2301	:	Introduction to Radiopharmacy
NMT2302	:	Nuclear Medicine Instrumentation Physics
NMT2303	:	Mathematics in Nuclear Medicine
NMT2304	:	Practicum - III
NMT2305	:	Clinical Practice
*****	:	Open Elective - I

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Introduction to Radiopharmacy						
Course Code		NMT2301						
Academic Year		Second						
Semester		III						
Number of Credits		4						
Course Prerequisite		Students should have basic knowledge of chemistry, human physiology and radiation physics						
Course Synopsis		This course will provide introductory knowledge of radiochemistry and radio-pharmacy as one of the core subjects of nuclear medicine. The knowledge will help students understand laboratory design, set up for various radiation facilities; prepare them for practical training in safe handling of radioactive material, and preparation of radiopharmaceuticals for clinical applications in Nuclear Medicine.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Outline and explain radio-pharmacy laboratory design and construction (C2)							
CO2	Compare and contrast the properties of radio-metals for various clinical and non-clinical applications (C2)							
CO3	Understand safe-handling of radioisotopes (C2)							
CO4	Explain radionuclide production methods and working concepts (C2)							
CO5	Summarize radiopharmaceutical use in nuclear medicine, the process of manufacturing to end use (C2)							
CO6	Understand basics of Tc- 99m radiopharmaceutical chemistry(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x							
CO3	x	x						
CO4	x	x						
CO5	x	x						
CO6	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
General Introduction	<ol style="list-style-type: none"> 1. Explain radio pharmacy as a subject, Practice, and Laboratory (C2) 2. Name basic radio-pharmacy Laboratory equipment, TLC Scanner, Fume Hood, Laminar Flow hood Balance, Centrifuge, Autoclave etc. and their applications in radio pharmacy laboratory (C1) 	2
Unit 2		
Radionuclides in Nuclear Medicine and General Laboratory safety	<ol style="list-style-type: none"> 1. What are the Physical and chemical Characteristics of radionuclides and Application in Nuclear Medicine (C1) 2. Explain Safety considerations in radio-pharmacy laboratory such as Electrical safety, chemical safety, Fire safety, Radiation safety, Biological safety (C2) 3. Make use of standard Radiation handling procedures: Receipt - storage - disposal of radioactive materials, International symbols of radioactivity labels (C2) 	8
Unit 3		
Design, Plan layout and setting up of Radio pharmacy Lab	<ol style="list-style-type: none"> 1. How to Classify Radio different type radiopharmacy Laboratories (C1) 2. Compare Operational Concept, design and Plan layout of Radio pharmacy Laboratory, Hospital Radio pharmacy and Centralized Radio pharmacy (C2) 3. Outline setting up of a typical Hospital radio pharmacy laboratory (C2). 4. Outline Role and responsibility of Staff in Hospital Radio pharmacy and Central Radio pharmacy (C2). 	7
Unit 4		
Production techniques for Radionuclides	<ol style="list-style-type: none"> 1. What are the methods of Artificial Production of Radionuclides - Primary (Nuclear reactors & Accelerators) and Secondary Sources (RN generators) (C1) 2. Explain Design, construction and working principle of typical nuclear reactor and medical cyclotron and radionuclide generator (C2) 3. Explain Factors affecting Production Yield (C2) 	13

Content	Competencies	Number of Hours
	4. What are the different types of radionuclide generators (C1) 5. Outline Ideal characteristics of generator system (C2) 6. Compare radiation characteristics of generator produced radionuclides (C2) 7. Explain Performance parameters for radionuclide generators (C2)	
Unit 5		
Radiopharmaceuticals: Cold kit Manufacture, labeling and Quality control	1. Classify- Diagnostic and Therapeutic Radiopharmaceuticals in Nuclear medicine (C2) 2. Outline Ideal Characteristics of Radiopharmaceuticals(C2) 3. Explain principles of Radio-labelling techniques: Radio-labelling, various methods of Radio-labelling- Direct & Indirect Labelling, factors affecting labeling efficiency(C2) 4. Explain mechanism of localization of Radiopharmaceuticals(C2) 5. Explain Cold Kits production and role of contents in labeling process (C2) <ol style="list-style-type: none"> Physical , pH quality checks Radionuclides Purity (RNP), Radiochemical Purity (RCP), Particle size and number Sterility, Pyrogenicity Bio-distribution studies. 	15
Unit 6		
99mTc- labelled Radiopharmaceuticals	1. Explain Technetium Chemistry (C2) 2. Explain Labeling with 99mTc- Sodium Pertechnetate (C2) 3. Outline Evolution of 99mTc-labelled Radiopharmaceuticals (C2) 4. Explain Coordination Chemistry of commonly used 99mTc-labelled Radiopharmaceuticals 5. Infer monographs for 99mTc-labelled Radiopharmaceuticals (C1)	15

Learning Strategies, Contact Hours and Out of class engagement:						
Learning Strategies	Contact Hours	Out of class engagement				
Lecture	45	45				
Seminar	13	13				
Revision	2	2				
Total	60	60				
Formative:		Summative:				
Quiz	Mid Semester (Theory)					
Unit tests	End semester (Theory)					
Assignments/ presentations						
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	x	-	-
Quiz / Viva/ Unit Test	x	x	x	x	x	x
End Semester Exam	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine - Kowalsky, Richard J., and Steven W. Falen 2. Fundamentals of Nuclear Pharmacy, 3 rd Edition Gopal B Saha					
Additional References	1. Radiopharmaceuticals and Hospital Radiopharmacy Practices - N. Ramamoorthy BRIT 2. Radiation safety in Nuclear Medicine - AERB Mumbai 3. Hand Book of Radiopharmaceuticals Mohan H Patel					

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Nuclear Medicine Instrumentation Physics						
Course Code		NMT2302						
Academic Year		Second						
Semester		III						
Number of Credits		04						
Course Prerequisite		Students should have basic knowledge of Radiation Physics and basic electronics						
Course Synopsis		This course covers physics and working principles of instruments used in Nuclear Medicine						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand various components and working principle of instruments in nuclear medicine counting (C2)							
CO2	Understand basic concepts behind calibration and quality control of nuclear medicine counting instruments (C2)							
CO3	Understand various components and working principle of imaging instruments in nuclear medicine counting (C2)							
CO4	Understand basic concepts behind calibration and quality control of nuclear medicine imaging instruments (C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						
CO4	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Gamma Ray Spectrometer	1. Explain basic principles of scintillation detectors (C2) 2. Explain basic principle and working of photomultiplier tube (C2) 3. Explain basic principle and working of photodiodes (C2) 4. Explain composition and some examples of Inorganic scintillators (C2) 5. Explain working of Inorganic scintillators (C2) 6. Explain Ideal characteristics of inorganic scintillators (C2) 7. Explain types of amplifiers used in GRS (C2) 8. Explain working of amplifiers (C2)	17

Content	Competencies	Number of Hours
	9. Explain working of pulse height analyser and coincidence circuit (C2) 10. Explain working of semiconductor detectors (C2) 11. Explain basic principle and working of Avalanche photodiodes (C2)	
Unit 2		
Gamma Probes in Nuclear Medicine	1. Explain working of a multichannel analyser (C2) 2. Explain basic design of thyroid uptake probe (C2) 3. Explain Iso-response curve (C2) 4. Explain Quality control procedures (C2) 5. Explain basic Components of gamma probe (C2) 6. Explain Instrument design and working of gamma probe (C2) 7. Explain basic Applications of gamma probe (C2) 8. Explain basic Quality control of gamma probe (C2)	11
Unit 3		
Liquid Scintillation and Whole Body Counters	1. Explain the Importance and need of liquid scintillation counting (C2) 2. Explain the Principle of liquid scintillation counting (C2) 3. Explain the Instrument design and working of liquid scintillation counter (C2) 4. Explain the Quenching and Quench correction methods (C2) 5. Explain the Applications of liquid scintillation counting and Quality control of liquid scintillation counter (C2) 6. Explain the Whole body counters working principle and instrumentation (C2) 7. Explain the Application of whole body counters, Quality control and applications (C2)	12
Unit 4		
Rectilinear scanners and Gamma camera	1. List Historical importance of rectilinear scanner (C1) 2. Explain the Working principle and instrument design of rectilinear scanners (C2) 3. Explain the drawbacks of rectilinear scanners (C2) 4. Explain the Introduction to gamma camera (C2) 5. Explain the Components of gamma camera (C1) 6. Explain the Detector system and event localization (C2) 7. Explain the Collimators and Performance characteristics of parallel hole collimators (C2) 8. Explain the Events in gamma camera (C2) 9. Explain Types of gamma camera and their use (C2) 10. Explain the Performance characteristics of a gamma camera (C2)	20

Content	Competencies	Number of Hours
	11.Explain Artifacts in gamma imaging (C2) 12.Explain the Correction methods in gamma imaging (C2) 13.Explain Gamma camera performance measurement-Spatial Resolution (C2) 14.Explain Gamma camera performance measurement-Energy Resolution and sensitivity (C2) 15.Explain Gamma camera performance measurement-Image uniformity and counting rate (C2)	

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	45	45
Seminar	9	9
Revision	2	2
Assessment	4	4
Total	60	60

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester/Sessional Exam (Theory)
Quiz	End Semester Exam (Theory)
Assignments/Presentations	

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester / Sessional Examination 1	x	x	-	-
Quiz / Viva/ Unit Test	x	x	x	x
End Semester Exam	x	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback

Main Reference:	1. Physics in Nuclear Medicine- Sorenson 2. Quality control of Nuclear Medicine instruments- Tecdoc-602 3. Radiation Detection and Measurement- Knoll G.F.
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Additional References	1. Mosby's Manual of Nuclear Medicine Procedures- D.Brucee Sodes, Paul J Early 2. Nuclear Medicine-Robert E. Henkin, Mark A. Boles 3. Computers in Nuclear Medicine-Lee Kai Hi
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Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Mathematics in Nuclear Medicine
Course Code	NMT2303
Academic Year	Second
Semester	III
Number of Credits	3
Course Prerequisite	Basic Knowledge of mathematics
Course Synopsis	This module will help to bridge the gap between the knowledge obtained in basic mathematics and applied Nuclear Medicine and provide fundamental knowledge of mathematics in various area like Radiopharmacy, Radiation Physics and Health physics in Nuclear Medicine.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Acquire and apply knowledge of trigonometry , functions and application in Nuclear Medicine (C3)
CO2	Explain Limits, differentiation, integration and its application (C2)
CO3	Apply knowledge of differential equation and their application in nuclear medicine (C3)
CO4	Apply the application of mathematics in radio-pharmacy and health physics (C3)
CO5	Apply the application of compartment analysis in nuclear medicine (C3)
CO6	Explain tracer kinetics and the application of tracer kinetics in nuclear medicine (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						
CO4	x	x						
CO5	x					x		
CO6	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Trigonometry & Functions and Application in Nuclear Medicine	1. Define Trigonometry- Introduction, angles, allied angles and inverse functions (C1) 2. Apply the use of trigonometry and functions (C3)	6

Content	Competencies	Number of Hours
	3. Choose the graphic representations in Nuclear Medicine (C3) 4. Define – Polynomial Functions (C1) and Describe exponential functions (C2) 5. Explain exponential and logarithmic Functions (C2) 6. Explain Graphical representation of trigonometric ratio and identify the amplitude, frequency. (C2)	
Limits & Derivatives	1. What is Limit and what is its use ? (C3) 2. What are Derivatives (C1) 3. Explain the derivative of some standard Functions (C2) 4. What are the Rules of differentiation(C1) and solve the derivatives of composite functions (C3) 5. Solve the differentiation of Implicit functions (C3) 6. Solve the Logarithmic functions (C3) 7. Explain successive differentiation.(C2) and solve (C3)	7
Integration	1. What is integration? What is Indefinite Integral (C1) 2. Explain Integration by the method of substitution (C2) 3. Explain the Integration by the method of partial fraction (C2) 4. Explain the integration by parts (C2) 5. Explain properties of definite Integral (C2)	7
Differential Equations and its application in Nuclear Medicine	1. What is Differential Equations.(C1) and Solve differential equations.(C3) 2. Construct the Differential Equations. (C3) and Solve differential equations. (C3) 3. Derive and solve the Attenuation coefficient of materials (C3) 4. Derive and justify the exponential equation of activity decaying (C4)	6
Unit 2		
Application of mathematics in radiopharmacy and health physics	1. Derive and analyze the Batmen equation (C3&C4) 2. Application of mathematics in radioactivity Calculation (C3) 3. Define unit conversion, and Explain the Specific Concentration of Activity.(C1,C2) 4. Solve the radiation exposure rate (C3)	6

Content	Competencies	Number of Hours
	5. Analyse the radiation exposure in different scenarios (C4) 6. Apply radiation exposure in Nuclear Medicine problems (C4)	
Compartment Analysis	1. Explain closed system and open system (C2) 2. Choose mathematical model (C3) 3. Classify the compartment analysis (C4) 4. Analyse the closed and opened compartment and Applied in Nuclear Medicine (C4) 5. Derive single compartment and application in Nuclear Medicine (C3 & C4) 6. Analyse the two compartment model in Nuclear Medicine (C4) 7. What is open Mammillary System, (C1)	7
Tracer Kinetics	1. Define tracer kinetics.(C1) and Explain specific requirements consideration in radiotracer kinetics. (C2) 2. Classification of radiotracer kinetics in Nuclear Medicine (C4) 3. Application of Radiotracer kinetics in Nuclear Medicine (C3) 4. Survey GFR Estimation by plasma sampling, and Explain PET kinetic analysis (C4)	6

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	25
Seminar	10	15
Assessment	5	5
Total	45	45

Assessment Methods:
Formative:

Unit Test

Assignments/Presentations

Summative:

Mid Semester Exam

End Semester Exam

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	-	-	-
Assignments/Presentations/ Unit test	x	x	x	x	-	x
End Semester Exam	x	x	x	x	x	x

Feedback Process:

Mid-Semester Feedback

End-Semester Feedback

Main Reference:	<ol style="list-style-type: none">1. Text Book of Mathematics for I & II year P.U.C. by Umarani B.G. Umarani P.G.2. Text Book of Mathematics by Grawel B.S.3. Text book of Radiation Physics by Ramesh Chandra
Additional References	<ol style="list-style-type: none">1. Nuclear Medicine by Robert E. Henkin, Mark A. Boles2. Accreditation Program for Nuclear Medicine Technologists in Radiation Safety. By P K Gaur3. Radiation Detection and Measurement- Knoll G. F.

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Practicum - III							
Course Code	NMT2304							
Academic Year	Second							
Semester	III							
Number of Credits	4							
Course Prerequisite	Students should have basic knowledge of chemistry, radiation physics, radiation safety, radiation instrumentation and electronics							
Course Synopsis	This course will provide comprehensive training in working with radioactive material and formulating radiopharmaceuticals for clinical use and also handling of various equipment used in Nuclear Medicine Department							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Demonstrate working of radio-pharmacy laboratory equipment (C2, P5)							
CO2	Demonstrate preparation of laboratory reagents (C2,P5)							
CO3	Demonstrate working and Quality control procedures radionuclide generator (C2,P5)							
CO4	Demonstrate preparation of radiopharmaceuticals and perform quality control procedures (C2,P5)							
CO5	Demonstrate quality control procedures of gamma camera(C2,P5)							
CO6	Demonstrate working and quality control procedures of non- imaging instruments (C2,P5)							
CO7	Demonstrate recording and analysis of human ECG (C2,P5)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	X	X				X		
CO2	X	X						
CO3	X	X				X		
CO4	X	X				X		
CO5	X	X				X		
CO6	X	X				X		
CO7	X	X						

Course Content and Outcomes:

Content	Competencies	Number of Hours (T/P)
Unit 1		
Radio pharmacy practicals:	1. To check functioning of fume hood (C2) (P5) 2. To demonstrate Radioactive storage and disposal (C2) (P5) 3. To demonstrate PH measurement of given sample (C2) (P5) 4. To prepare Buffer solutions (C2) (P5) 5. To demonstrate separation of ^{99m} Tc with Organic Solvent extraction method (C2) (P5) 6. To demonstrate elution and calculation of elution efficiency of ^{99m} Tc from Column generator (C2) (P5) 7. To demonstrate Sterilization of Sodium Pertechnate (C2) (P5) 8. To demonstrate Parent Daughter decay Growth Relationship in Technetium generator (C2) (P5) 9. To demonstrate Molybdenum Breakthrough Assay of Sodium Pertechnate (C2) (P5) 10. To demonstrate Aluminium Breakthrough Assay of Sodium Pertechnate (C2) (P5) 11. To illustrate Radiochemical Purity of Sodium Pertechnate by Paper Chromatography (C2) (P5) 12. To preparation ^{99m} Tc labelled DTPA, MDP, Mebrofenin (C2) (P5) 13. To preparation ^{99m} Tc labelled, ECD, EC, Sulphur Colloid, MIBI (C2) (P5) 14. To perform Quality control of ^{99m} Tc labelled Radiopharmaceuticals. (C2) (P5) 15. To learn dispensing and administration techniques for ^{99m} Tc-Radiopharmaceuticals for patients (C2) (P5)	53
Unit 2		
Nuclear Medicine Instrumentation practicals:	1. To perform quality control of dose calibrator (C2) (P5) 2. To determine the operational characteristics of GM counter (C2) (P5) 3. To compare the dead time of GM counter for different radioactive sources (C2) (P5) 4. To perform energy calibration of gamma ray spectrometer (C2) (P5) 5. To demonstrate the role of linear amplifier in pulse shaping and amplification of pulse received from photomultiplier tube /	52

Content	Competencies	Number of Hours (T/P)
	preamplifier in a Gamma ray spectrometer (C2) (P5) 6. To demonstrate energy linearity of gamma ray spectrometer using different radioisotopes (C2) (P5) 7. To identify unknown radionuclide using gamma ray spectrometer (C3) (P5) 8. To determine activity of given radioisotope using gamma ray spectrometer (C3) (P5) 9. To perform thyroid uptake study (C2) (P5) 10. To demonstrate human ECG recording and analyze it for QRS voltage and frequency (C4) (P5) 11. To perform ECG measurements and carry out manual electrical axis analysis (C4) (P5) 12. To perform sensitivity test of gamma camera (C2) (P5) 13. To perform uniformity test of gamma camera (C2) (P5) 14. To perform spatial resolution and linearity tests of gamma camera (C2) (P5) 15. To demonstrate working of thyroid uptake probe (C2) (P5)	

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement				
Lecture	15	15				
Practical	82	82				
Revision	8	8				
Total	105	105				
Formative:	Summative:					
Quiz	Mid Semester (Practical)					
Viva	End semester (Practical)					
Practical record book	Record Book					
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	-	x	-
Quiz / Viva	x	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x	x
End Semester Exam	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					

Main Reference:	<ol style="list-style-type: none">1. Nuclear Medicine Technology & Techniques Third Ed Donald Bernier et.al2. Physics in Nuclear Medicine, Sorenson
Additional References	<ol style="list-style-type: none">1. Mosby's Manual of Nuclear Medicine Procedures, D.Brucee Sodee,Paul J Early2. Quality control of Nuclear Medicine instruments, Tecdoc 602

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Clinical Practice						
Course Code		NMT2305						
Academic Year		Second						
Semester		III						
Number of Credits		2						
Course Prerequisite		Students should have basic knowledge of basic science subjects, radiation physics, Radiopharmacy and nuclear medicine instrumentation.						
Course Synopsis		This course will give training for the candidate to prepare & safely handle the radiopharmaceuticals for clinical applications in Nuclear Medicine department, expose them to the different imaging and non-imaging Nuclear Medicine procedures, to maintain documentations and stock inventory.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand safe handling of radioisotopes and practice radiation safety (C3, P3)							
CO2	Understand the basic applications of Radiopharmacy in clinical nuclear medicine practice (C3, P3)							
CO3	Understand the basic applications of Instrumentation in clinical nuclear medicine practice. (C3, P3)							
CO4	Understand different imaging and non-imaging Nuclear Medicine procedures (C3, P3)							
CO5	Maintain documentations and stock inventory (C3, P3)							
CO6	Learn the importance of effective communication, team work, ethical values and professionalism(C3, P3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x				x			
CO2	x	x						
CO3		x					x	
CO4		x		x				
CO5	x	x						
CO6			x		x			

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Radiopharmacy Practices	<ol style="list-style-type: none"> 1. To arrange Radiopharmacy lab for daily activities (C1, P3) 2. To identify and produce the inventory (C2, P3) 3. To practice QC of dose calibrator (C3, P3) 4. To prepare and dispense radiopharmaceuticals (C3, P3) 5. To practice QC of radiopharmaceutical (C3, P3) 6. To express procedures to patient and to practice as per regulatory guidelines (C2, P3) 7. To write and maintain registers (C3) 	17
Unit 2		
In-vitro Nuclear Medicine Practices	<ol style="list-style-type: none"> 1. To locate and identify stock inventory (C2, P3) 2. To operate various non-imaging and radiation monitoring equipments (C3, P3) 3. To produce radiation surveillance reports (C3) 4. To write and maintain registers (C3) 	13
Unit 3		
Scintigraphy Practices	<ol style="list-style-type: none"> 1. To arrange imaging room for daily activities (C1, P3) 2. To practice daily QC of imaging and other accessory devices (C3, P3) 3. To express procedures to patient and to practice as per regulatory guidelines (C2, P3) 4. To practice scans and processing techniques (C3, P3) 5. To write and maintain registers (C3) 	13
Unit 4		
Radiation Therapy Practices	<ol style="list-style-type: none"> 1. To locate and identify stock inventory (C2) 2. To practice QC of dose calibrator (C3, P3) 3. To prepare and dispense radiopharmaceuticals (C3, P3) 4. To practice QC of radiopharmaceutical (C3, P3) 5. To express procedures to patient and to practice as per regulatory guidelines (C2, P3) 6. To produce radiation exposure records (C3) 7. To write and maintain registers (C3) 	17

Learning Strategies, Contact Hours and Out of class engagement:						
Learning Strategies	Contact Hours	Out of class engagement				
Lecture	15	15				
Self-directed learning (SDL)	-	20				
Problem Based Learning (PBL)	10	15				
Case Based Learning (CBL)	10	5				
Clinic	25	5				
Total	60	60				
Formative:			Summative:			
Quiz			Mid Semester (Practical)			
Viva			Viva			
Clinical assessment (OSCE, OSPE, WBPA)			Log Book			
Clinical Log Book			End Semester Exam: NA			
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	x	x	x
Quiz / Viva	x	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x	x
Any others: WPBA	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine - Kowalsky, Richard J., and Steven W. Falen 2. Nuclear Medicine-The Requisites : Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall					
Additional References	1. Radiopharmaceuticals and Hospital Radiopharmacy Practices - N. Ramamoorthy BRIT 2. Radiation safety in Nuclear Medicine - AERB Mumbai 3. Nuclear Medicine Technology: Procedures and Quick Reference – Pete Shackett					

SEMESTER - IV

Course code	:	Course Title
BST3401	:	Biostatistics and Research Methodology
NMT2401	:	Radiobiology
NMT2402	:	Health Physics
NMT2403	:	Practicum - IV
NMT2404	:	Clinical Practice
NMT ****	:	Program Elective - I

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Biostatistics and Research Methodology
Course Code	BST3401
Academic Year	Second
Semester	IV
Number of Credits	3
Course Prerequisite	Nil
Course Synopsis	1. To provide necessary foundation on <ul style="list-style-type: none"> • Introductory level biostatistics • Demography, vital statistics and epidemiology • Survey sampling methods • Fertility, morbidity, and mortality indices 2. To introduce the steps involved in research process

Course Outcomes (COs): At the end of the course student shall be able to:

CO1	Summarize the variable types, scales of measurement and understand the role of biostatistics in health professions. (C2)
CO2	Apply appropriate descriptive statistics, visualizations, point, interval estimation, and Confidence Interval, parametric and non-parametric tests to variables in healthcare studies. (C3)
CO3	Outline the sources of demographic data and vital statistics, merits and demerits of Sampling distribution, probability and non-probability sampling techniques. (C2)
CO4	Explain the steps involved in a research process, epidemiology and observational study designs. (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2	x	x						
CO3	x	x						
CO4	x					x		

Course Content and Outcomes:

Content	Competencies	Number of Hours
Module 1: Introductory Biostatistics		
Introduction to Biostatistics	<ul style="list-style-type: none"> • Define statistics and biostatistics. (C1) • Describe the limitations and characteristics of biostatistics. (C2) • Explain the role of statistics in health sciences. (C2) 	3

Content	Competencies	Number of Hours
Variables	<ul style="list-style-type: none"> Summarize the types of variables with examples. (C2) Distinguish between qualitative & quantitative with appropriate examples. (C2) Distinguish between continuous & discrete variables with appropriate examples. (C2) 	
Scales of Measurement	<ul style="list-style-type: none"> Describe nominal, ordinal, interval and ratio scale of measurement of variables with appropriate examples. (C2) Distinguish between the four scales of measurement. (C2) 	
Module 2: Descriptive Statistics		
Summarizing Data: Tabulation Methods	<ul style="list-style-type: none"> Illustrate the qualitative, quantitative and chronological classification to tabulate and summarize data. (C3) 	6 +1 SDL
Summarizing Data: Graphical Methods	<ul style="list-style-type: none"> Describe graphical methods to summarize data: Pie chart, Bar chart, Line Plot, Histogram, Frequency Curve and Frequency Polygon. (C2) 	
Measures of Central Tendency	<ul style="list-style-type: none"> Explain the concepts of Mean, Median, Mode. (C2) Explain the concepts of Quartiles and Percentiles. (C2) 	
Measures of Dispersion	<ul style="list-style-type: none"> Describe the concepts of Range, Inter-quartile range, Variance, Standard deviation and Coefficient of variation. (C2) Explain the concept of skewness and describe three types of skewness. (C2) Explain the concept of kurtosis and describe three types of kurtosis. (C2) 	
Module 3: Introduction to Probability and Normal Distribution		
Probability: An Introduction	<ul style="list-style-type: none"> Define the relative frequency approach to probability. (C1) 	3
Normal Distribution	<ul style="list-style-type: none"> Explain the characteristics of normal distribution. (C2) Compute the area under the normal distribution curve. (C3) 	
Module 4: Sampling Methods		
Need for Sampling	<ul style="list-style-type: none"> Explain the need for sampling and the advantages of sampling over complete enumeration. (C2) Explain sampling and non-sampling error. (C2) Define and distinguish probability and non-probability sampling methods. (C1) 	3

Content	Competencies	Number of Hours
Random Sampling Methods	<ul style="list-style-type: none"> Explain the uses and situation of each sampling technique and mention merits and demerits. (C2) 	
Non-random Sampling Methods	<ul style="list-style-type: none"> Explain the uses and situation of each sampling technique and mention merits and demerits. (C2) 	
Module 5: Introduction to Correlation and Regression Analysis		
Correlation Analysis	<ul style="list-style-type: none"> Define correlation and its properties. (C2) Explain types of correlation with diagrams and appropriate examples. (C2) Illustrate using scatter plot the different types of correlation.(C3) Explain the Pearson's correlation coefficient and outline its properties. (C2) Explain the Spearman's correlation coefficient and outline its properties. (C2) 	4
Regression Analysis	<ul style="list-style-type: none"> Distinguish between dependent and independent variables. (C2) Explain the simple linear regression model along with the assumptions involved. (C2) Identify the slope and intercept coefficient from the model. (C2) Predict the dependent variable from the model for a given set of independent variables. (C3) 	
Module 6: Testing of Significance		
Understanding population, sample, parameter and statistics, estimate and estimator	<ul style="list-style-type: none"> Define and differentiate parameter and statistic with examples. (C2) Define the basic terms-population, sample, sampling, parameter, statistic, estimate and estimator, point estimate. (C1) Define and differentiate standard deviation and standard error. (C2) 	6 +2 SDL
Sampling distribution/standard error	<ul style="list-style-type: none"> Determine the sampling distribution/standard error of sample mean, sample proportion, difference between two means, difference between two proportions (Large sample approximation (CLT).(C3) 	
Confidence Interval	<ul style="list-style-type: none"> Construct and interpret confidence interval for mean, difference between two means, proportion, difference between two proportions (large sample approximation). (C3) 	
Module 7: Testing of Hypothesis		
General procedure of	<ul style="list-style-type: none"> Define/explain with example the concept of null hypothesis, alternative hypothesis, type I and 	6

Content	Competencies	Number of Hours
testing of hypothesis	type II errors. Define level of significance, power of the test and p-value, one sided and two-sided test. (C2)	
Parametric test: Single mean test, difference between two means test, and paired t test.	<ul style="list-style-type: none"> Explain the differences, merits and demerits of parametric and non-parametric over parametric tests. (C2) 	
Non-Parametric test: Chi-square test, Mann-whitney test, Sign test	<ul style="list-style-type: none"> Give the situation for parametric and non-parametric tests. (C2) 	
Module 8: Introduction to Research Methodology		
Research Methodology, Research Design and Review of Literature	<ul style="list-style-type: none"> Explain the research process and describe various research designs with flowchart. (C2) Explain different methods of data collection and data sources. (C2) 	4 +2 SDL
Module 9: Vital Statistics and Epidemiology		
Introduction to demography, vital statistics and epidemiology	<ul style="list-style-type: none"> Define Epidemiology, Demography and Vital statistics. (C1) What are the sources of demographic data and vital statistics. (C1) 	3 +2 SDL
Morbidity, mortality and fertility rates	<ul style="list-style-type: none"> Define and distinguish rate, ratio and proportion (C1) Explain prevalence and incidence. (C2) Explain each measure of morbidity, mortality and fertility rates by stating the formula. (C2) 	
Observational Study Design	<ul style="list-style-type: none"> Explain the observational study designs (case report, case series, case-control, cross-sectional, ecological). (C2) 	

Learning Strategies, Contact Hours and Out of Class Engagement		
Learning Strategies	Contact Hours	Out of Class Engagement
Lecture	38	38
SDL	7	22
Total	45	60
Assessment Methods:		
Formative:	Summative:	
Unit Test	Mid Semester Exam	
	End Semester Exam	

Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	x	-
End Semester Exam	x	x	x	x
Feedback Process:	End-Semester Feedback			
Main Reference:	<ol style="list-style-type: none"> 1. Lwanga SK, Tye CY, Ayeni O. Teaching health statistics: lesson and seminar outlines. World Health Organization, Marketing and Dissemination, 1211 Geneva 27, Switzerland; 1999. 2. Health research methodology: a guide for training in research methods. World Health Organization; 2001. 3. Bonita R, Beaglehole R, Kjellström T. Basic epidemiology. World Health Organization; 2006. 4. Campbell MJ, Swinscow TD. Statistics at square one. John Wiley & Sons; 2011. 			
Additional References	<ol style="list-style-type: none"> 1. Daniel, W. W., and Cross, C. L. (2018). Biostatistics: a foundation for analysis in the health sciences. Wiley. 2. Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International. 3. Rosner, Bernard, (2010). Fundamentals of Biostatistics, 7th Edition, Duxbury Press. 4. Peter Armitage, Geoffrey Berry, J. N. S. Matthews, (2002). Statistical Methods in Medical Research, 4th Edition, Blackwell. 5. Wayne W. Daniel, (2004). Biostatistics_ A Foundation for Analysis in the Health Sciences, 8th Edition, Wiley Series in Probability and Statistics. 			

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Radiobiology
Course Code	NMT2401
Academic Year	Second
Semester	IV
Number of Credits	3
Course Prerequisite	Students should have basic knowledge of radiation physics, radiation detection and measurement, cell and molecular biology
Course Synopsis	The course aims to provide a mechanistic understanding of the biological processes involved in the interaction of ionizing radiation with living systems. This will help the student to know the relative risks and benefits of radiation and understand safety and regulatory aspects involved in personal protection and patient care.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain modes and mechanisms of radiation interactions with the biological system (C2)
CO2	Explain the various type of radiation effects and the pathophysiological nature of radiation induced damage on the biological system (C2)
CO3	Compare the role of modifying factors in altering the biological sensitivity to radiation. (C3)
CO4	Summarize detrimental effects of radiation on foetal development at various levels of radiation exposure (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2	x						x	
CO3	x						x	
CO4	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Bio-molecular and Cellular Radiobiology	1. Outline major events in radiation interaction with biological system (C2) 2. Explain radiation chemistry and formation of free radicals (C2)	18

Content	Competencies	Number of Hours
	3. Compare direct and indirect interaction of radiation (C2) 4. Explain radiation interaction with DNA and chromosomes (C2) 5. Explain radiation Geno toxicity assessment (C2) 6. Explain radiation Cell death mechanisms and interpret cell survival assays (C2) 7. Identify Factors affecting cell radio-sensitivity/ survival fraction/radio-resistance (C3) 8. Compare Stochastic and deterministic effects of radiation (C2) 9. Compare Acute and delayed effects of radiation (C2) 10. Compare Whole body and localized organ exposure (C2)	
Unit 2		
Early radiation effects	1. Apply the concept of Lethal dose (C3) 2. Explain acute radiation syndrome (C2) 3. Explain NVD syndrome (C1) 4. Summarize Central nervous system syndrome, radiation dose related pathological changes (C2) 5. Summarize Gastrointestinal syndrome, radiation Dose related pathological changes (C2) 6. Summarize Bone marrow syndrome, radiation dose related pathological changes (C2)	13
Unit 3		
Delayed radiation effects	1. Explain and Identify Late deterministic effects (C3) 2. Explain and Identify Late stochastic effects (C3) 3. Explain Models for estimating radiation associated cancer risk (C2)	5
Unit 4		
Radio-sensitizers and radio-protectors	1. Explain role of heat as radio-sensitizer (C2) 2. Explain role of antioxidants as radio-protectors (C2)	4
Unit 5		
Radiation effects on embryo	1. What are the various phases of Embryo development? (C1)	5

Content	Competencies	Number of Hours
	2. Outline dose dependent Effects of prenatal irradiation (C2) 3. Compare and contrast radiation effects on animal and humans (C2)	

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	25
Seminar	13	15
Revision	2	5
Total	45	45
Formative:	Summative:	
Quiz	Mid Semester (Practical)	
Assignment/seminars	End semester	
Unit test		

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	-	-
Quiz / Viva/ Unit Test	x	x	x	x
Assignment/seminars	x	x	x	x
End Semester Exam	x	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback
Main Reference:	1. Radiation Biology and Physics- Paul F Wilson and Joel S Bedford 2. Radiobiology for the Radiologist –Eric J Hall, and Amato J Giaccia Uma Devi
Additional References	1. Biological assessment of Radiation Damage – Thomas. L, Walden.Jr and Nushin K 2. Radiation safety in Nuclear Medicine - AERB Mumbai 3. Radiation biology – Devi P .Uma ,Nagarathnam A and Rao BSS

Manipal College of Health Professions	
Name of the Department	Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Health Physics
Course Code	NMT2402
Academic Year	Second
Semester	IV
Number of Credits	3
Course Prerequisite	Students should have knowledge in Basics of Nuclear Medicine and safety
Course Synopsis	<ol style="list-style-type: none"> 1. This course covers the basics in Nuclear Medicine and safety needed for nuclear medicine technology. 2. The course describes the effects of ionizing radiation on living organisms. 3. To assist the students to learn the basic Nuclear Medicine in order to understand the concept of the sealed and unsealed radioisotopes and their uses in the treatment of cancer 4. The course emphasizes radiation Safety Consideration in Radionuclide therapy 5. To deal with the different imaging techniques used in nuclear medicine and physics behind detectors and to identify the fundamentals of nuclear medicine facilities and their applications in day today life.
Course Outcomes (COs):	
At the end of the course student shall be able to:	
CO1	Explain the basic principles of radiation protection, the fundamental factors by which radiation hazards can be controlled, ALARA principle, HVL, TVL, the nuclear medicine laboratories, delay tank, isolation ward, dose limitations for the discharge of effluents and patients and to solve related problems(C3, A3, P3)
CO2	Explain direct and indirect surface contamination, ALI, DAC, Survey meters, contamination monitors, personal dosimeters dose limits prescribed by the IAEA-BSS and the ICRP for occupational and public, Radiation safety aspects for patients referred for ablation and toxic therapy, precautions, discharge criteria, dose optimization, handling bedridden patients and other radionuclide therapies (C2, A3, P3)
CO3	Explain A1 and A2 values for transport, safe transport of radioactive material, transport index, classification of radioactive packages (C2,A3, P3)
CO4	Explain concepts and principle of radioactive waste management, on radioactive waste management in Nuclear Medicine, practical examples, fixed and loose contamination, contamination limits Regulatory aspects ,duties of RSO, employer, radiation worker and the licensee, emergency response accessories, emergency planning and preparedness (C2, A3, P3)

CO5	Explain misadministration in nuclear medicine, types, consequences, causes and preventive measures taken to avoid misadministration, emergency situation in NM, spillage of radioactive material, dealing with emergency situation, handling cadaver administered with radionuclides, decontamination procedures. (C2, A3, P3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						
CO4		x	x					
CO5		x	x					

Course Content and Outcomes:

Content	Competencies	Number of Hours
Basic Radiation physics	1. Recall on what is atomic structure, atomic number, mass number, isotopes, radioisotopes, types of type of radioactive disintegration electron capture isometric transition. (C1 P1) 2. Tell the characteristic of alpha, beta and gamma ray; energy of ionising radiation (C1,P1) 3. Define half life physical biological mean life effective half life. (C1,P1) 4. Recall on secular, transient and no equilibrium, production of radio isotope and X –rays (characteristic and Bremsstrahlung), neutron source. (C1, P1)	1
Interaction of radiation with matter	1. Recall on a interaction of charged particle with matter, range of charged particles, interaction of photon with a matter photoelectric, Compton scattering and pair production), absorption, scattering and attenuation of photons, interaction of neutrons with matter(C1,P1) 2. Define half value thickness(HVT) and 10th value thickness (TVT), (C1,P1)	1
Radiation quantities and unit	Define (C1) 1. Activity (Becquerel /Curie) 2. Energy, exposure (C/kg/ Roentgen), 3. LET, 4. Charge particles equilibrium (CPE), 5. Linear and mass attenuation coefficient, 6. Mass stopping power, 7. Air kerma, 8. Terma, 9. Absorbed dosea (Gray/ rad), 10.Radiation weighting factor (WR)	2

Content	Competencies	Number of Hours
	11. Tissue weighting factor 12. equivalent dose 13. effective dose 14. collective effective dose person SV 15. annual limit of intake ALI becquerel 16. derived air concentration DAC becquerel/m ³ 17. personnel dose equivalent 18. committed dose	
Basic radio biology	1. Explain on interaction of radiation with cell, direct and indirect interactions, radiation effect and time scales (C2) 2. Explain on molecular effect of radiation and their modifiers, chromosomal abbreviation, somatic and genetic effects, DNA damage and repair, cellular effect of radiation (C2) 3. Explain on what biological effects of radiation on tissue fetus and tumours are, deterministic and stochastic effect (C1, C2)	3
Operational limits	1. Introduction to natural background radiation, tell the concept of occupational risk (C1) 2. Explain on philosophy of radiation protection system of dose limitation ALARA dose limit to radiation workers general public's dose constraint for comfort of patient. (C2) 3. Explain and list on AERB/ICRP recommendation (C2)	3
Radiation detection and Measurement	1. Explain on principle of radiation detection, various gas detector (ionization chamber proportional counter and GM counter), solid state detector (scintillator, semiconductor and Thermoluminescent Dosimeter (TLD) and liquid scintillation counting system. (C2) 2. Explain on nuclear counting statistics, confidence level of measurement (C2) 3. Explain radiation monitoring, direct reading device. (C2) 4. Explain on calibration and response of radiation monitoring instruments. (C2)	4
Radiation hazard Evaluation and control	1. List on internal and external radiation hazard and their perspective. 2. Explain on evaluation and control of hazard due to external radiation, individual and workplace monitoring application of time, distance and shielding, specific gamma ray constant, external radiation monitoring, survey meters. (C2) 3. Explain on internal hazard evaluation and control, protective measures for handling of unsealed	4

Content	Competencies	Number of Hours
	<p>source (e.g fume hood, glove box), environment control, protective clothing. (C2)</p> <p>4. Explain on contamination monitoring direct and indirect, air contamination monitoring, personal contamination monitoring and decontamination procedure surface decontamination procedure. (C2)</p>	
Working principle of nuclear Medicine Equipment	<p>1. Recall on working principle of isotope calibrator planar gamma camera, SPECT (C1)</p> <p>2. Recall on working principle of PET, PET -CT and Medical cyclotron. (C1)</p>	2
Radiation Dosimetry	<p>1. Explain and derive single compartmental model and 2 compartmental model with and without back transference (C2).</p> <p>2. Explain in vivo dosimetry using classical dosimetry mechanism (C2)</p> <p>3. Explain</p> <ul style="list-style-type: none"> • Beta dosimetry • Gamma dosimetry • Geometrical factor explain the Dosimetry of low energy Electromagnetic radiation (C2) • Explain and derive MIRD formulation (C2) • Define <p>1. unulated activity</p> <p>2. equilibrium absorbed dose constant absorption factor</p> <p>3. specific absorption fraction</p> <ul style="list-style-type: none"> ○ Explain the doors reciprocity theorem ○ Define mean dose per cumulated activity (C1) ○ List the limitation of MIRD method (C1) ○ what is extremity dosimetry (C1) 	5
Quality control (QC) in nuclear medicine	<p>1. List the importance of QC in nuclear medicine. (C1)</p> <p>2. Explain on the test parameters and procedure of QC of isotopes calibrator, planer gamma camera system, SPECT. (C2)</p> <p>3. Explain on test parameters and procedure for QC of PET, PET-CT and radio pharmaceuticals. (C2)</p>	2
Radionuclide therapy radiation safety Aspect	<p>1. List the various radio nuclei administration technique.(C1)</p> <p>2. Explain and summarise on pre and post therapy precaution, narsingh care, patient monitoring and discard criteria (C2)</p> <p>3. Explain on optimization of radiation radiation dose to non-target tissue, radiation safety consideration in treatment of Ca-thyroid, palliative bone, metastases and other therapeutic procedures such as radiation synovectomy peptide therapy etc. (C2)</p>	2

Content	Competencies	Number of Hours
Disposal of Radioactive waste	<ol style="list-style-type: none"> 1. Explain on origin and types of waste, classification of wastes and methods of disposal, disposal of short-lived solid, liquid and gaseous radioactive waste.(C2) 2. Explain on disposal of animal carcasses and radioactive foliage disposal limits for ground burial and sanitary sewage system incineration disposal of long-lived and indispersible radioactive waste (C2) 	3
Planning of nuclear medicine facilities	<ol style="list-style-type: none"> 1. Explain on classification and general features of NM laboratories (site, typical floor plans, ventilation, surface, walls, floor and ceiling, work surfaces, containment systems, fume-hood, glove box etc) (C2) 2. Explain on planning of NM laboratories, such as diagnostic and high dose therapy, PET-CT and medical cyclotron installation, shielding evaluation of NM laboratories and medical cyclotron (C2) 3. Outline on model layouts of various NM laboratories, commissioning, decommissioning. (C2) 	3
Transport of Radioactive material	<ol style="list-style-type: none"> 1. Explain on rules governing transport of radioactive material, introduction, terms used (e.g. Competent Authority, A1 & A2 values, Transport Index (TI) etc.), transport scenarios (routine, normal & accident), types of packages covered under the transport regulations, general requirement of all packaging, requirements for transport of radioactive material in liquid form, expected limit, special form and other than special form. (C2) 2. Explain on TREMCARD, procedure for packing, marking, labelling transport documents responsibilities of consignor and consignee, consignor's declaration, instruction to the carrier, transport of surface contaminated objects, off-normal situations during transport of radioactive materials, handling off-normal situation, emergency planning.(C2) 	3
Radiation Accidents, Case Studies and lesson Learns	<ol style="list-style-type: none"> 1. Explains on radiation accidents involving radioisotopes, orphan and vulnerable sources, handling of emergency situations, resulting from spillage of radiopharmaceuticals/liquid radioisotopes, misadministration of radiopharmaceuticals and its consequences. 2. Explain on general method of prevention of accident, loss of radioisotope fire accident and explosion; follow up action through emergency response plan, case study and mitigation lesson learned. 	3

Content	Competencies	Number of Hours
Regulatory aspect of nuclear medicine facilities	1. Explain on regulation with respect to nuclear medicine laboratory relevant regulatory documents such as act, rule, code, standards and Guides, responsibility of employer, licence, radiation safety officer RSO, technologists and radio isotope supplier safety and security of radioactive source during transport any storage inventory control. 2. Explain on security provision: administrative and technical measures, graded approach in security provision, physical protection system, regulatory requirement for import/ export, procurement, use handling transfer and disposal of radioisotope inventory control, Radiation protection programme RPP e licensing procures in India.	2
Emergency response plan and preparedness	1. List and explain on normal and potential exposure accident situation involving radioisotopes element of emergency planning and preparedness including procedure for notification and communication administrative and technical procedure emergency response accessories responsibilities of employer licence RSO technologists and radio isotope/equipment supplier in case of emergencies.	2

Learning Strategies, Contact Hours and Out of class engagement:					
Learning Strategies	Contact Hours	Out of class engagement			
Lecture	30	25			
Revision	8	15			
Assessment	7	5			
Total	45	45			
Assessment Methods:					
Formative:			Summative:		
Unit Test			Mid Semester/Sessional Exam (Theory)		
Assignments/Presentations			End Semester Exam (Theory)		
Mapping of Assessment with COs:					
Nature of Assessment	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	x	x	-	-	-
Assignments/presentations	x	x	x	x	x
Unit test	x	x	x	x	x
End Semester Exam (Theory)	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback				
	End-Semester Feedback				

Main Reference:	1. Physics in Nuclear Medicine - Simon R. Cherry, James A. Sorenson, and Michael E
Additional References	2. Fundamentals of Nuclear Pharmacy, Fifth Edition- Gopal B. Saha, Ph.D. 3. Nuclear Medicine Therapy: Principles and Clinical Applications 4. By Aktolun, Cumali, Goldsmith, Stanley J. (Eds.) 5. Nuclear Medicine Physics: The Basics 8th Edition by Ramesh Chandra and Arman Rahmim, Wolters Kluwer Lippincott Williams and Wilkins

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Practicum - IV							
Course Code	NMT2403							
Academic Year	Second							
Semester	IV							
Number of Credits	3							
Course Pre-requisite	Students should have basic knowledge of radiation biology, in-vitro radioactive diagnostic procedures , radiation safety and radiation measurement							
Course Synopsis	This course will provide students practical skills to quantify radiation-induced biological damage and perform in-vitro diagnostics. It will also help them understand the need and ways to implement radiation safety guidelines in their daily practice as radiation workers.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Practically demonstrate radiation induced cellular and DNA damage (C3, P5)							
CO2	Perform radioactive non imaging diagnostic procedures (C3, P5)							
CO3	Understand radiation safety rules and perform radiation surveillance following safety guidelines (C3, P5)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x					x		
CO2		x				x		
CO3		x				x		

Course Content and Outcomes:

Content	Competencies	Number of Hours (T/P)
Unit 1		
Radiobiology Practicals	1. To demonstrate the damaging effect of gamma and beta radiations on DNA (C3) (P5) 2. To demonstrate genotoxicity of various agents using micronucleus assay(C3) (P5) 3. To demonstrate chromosomal aberrations induced by various agents(C3) (P5) 4. To demonstrate effect of ionizing radiations on red blood cells (C3) (P5)	24
Unit 2		
In vitro Nuclear Medicine techniques	1. To perform sample collection, storage and centrifugation of biological samples (C1)(P5)	20

Content	Competencies	Number of Hours (T/P)
practicals	2. To measure samples weight and volume using electronic balance and glass pipette (C1) (P5) 3. To demonstrate RIA (C3) (P5) 4. To demonstrate IRMA (C3) (P5) 5. To perform thyroid uptake study (C3) (P5) 6. To calculate GFR by single plasma sampling method (C3) (P5) 7. To perform radio-respirometry assay (C3) (P5)	
Unit 3		
Health Physics and Radiation protection	1. To perform radiation area survey (C1) (P5) 2. To perform radiation decontamination (C2) (P5) 3. To demonstrate the effect of time on radiation exposure (C2) (P5) 4. To demonstrate the effect of distance on radiation exposure (C2) (P5) 5. To demonstrate the effect of shielding on radiation exposure (C2) (P5) 6. To perform calibration of contamination Monitor using standard source(s) (C3) (P5) 7. To perform calibration of radiation survey meter using standard source(s) (C3) (P5)	31

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	15	15
Practical	60	60
Revision	0	-
Total	75	75
Formative:	Summative:	
Quiz	Mid Semester (Practical)	
Viva	End semester (Practical)	
Practical record book	Record Book	

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3
Mid Semester Examination	-	x	x
Quiz / Viva	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x
End Semester Exam	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback
Main Reference:	<ol style="list-style-type: none"> 1. Nuclear Medicine Technology & Techniques Third Ed Donald Bernier et.al 2. Physics in Nuclear Medicine, Sorenson
Additional References	<ol style="list-style-type: none"> 1. Mosby's Manual of Nuclear Medicine Procedures, D.Bruce Sodee, Paul J Early 2. Radioimmuno assay- Principles and Practice, Pillai & Bhandarkar

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Clinical Practice							
Course Code	NMT2404							
Academic Year	Second							
Semester	IV							
Number of Credits	5							
Course Prerequisite	Students should have basic knowledge of basic science subjects, radiation physics, Radio-pharmacy and nuclear medicine instrumentation.							
Course Synopsis	This course will give training for the candidate to prepare & safely handle the radiopharmaceuticals for clinical applications in Nuclear Medicine department, expose them to the different imaging and non-imaging Nuclear Medicine procedures, to maintain documentations and stock inventory.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand safe handling of radioisotopes and practice radiation safety (C3, P3)							
CO2	Understand the basic applications of Radio-pharmacy in clinical nuclear medicine practice (C3, P3)							
CO3	Understand the basic applications of Instrumentation in clinical nuclear medicine practice. (C3, P3)							
CO4	Understand different imaging and non-imaging Nuclear Medicine procedures (C3, P3)							
CO5	To maintain documentations and stock inventory (C3, P3)							
CO6	Learn the importance of effective communication, team work, ethical values and professionalism(C3, P3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x				x			
CO2	x	x						
CO3		x					x	
CO4				x		x		
CO5	x	x						
CO6			x		x			

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Radiopharmacy Practices	1. To arrange radio-pharmacy lab for daily activities (C1, P3) 2. To identify and produce the inventory (C2, P3) 3. To practice QC of dose calibrator (C3, P3) 4. To prepare and dispense radiopharmaceuticals (C3, P3) 5. To practice QC of radiopharmaceutical (C3, P3) 6. To express procedures to patient and to practice as per regulatory guidelines (C2, P3) 7. To write and maintain registers (C3, P3)	54
Unit 2		
In-vitro Nuclear Medicine Practices	1. To locate and identify stock inventory (C2, P3) 2. To operate various non-imaging and radiation monitoring equipments (C3, P3) 3. To produce radiation surveillance reports (C3) 4. To write and maintain registers (C3)	40
Unit 3		
Scintigraphy Practices	1. To arrange imaging room for daily activities (C1, P3) 2. To practice daily QC of imaging and other accessory devices (C3, P3) 3. To express procedures to patient and to practice as per regulatory guidelines (C2, P3) 4. To practice scans and processing techniques (C3, P3) 5. To write and maintain registers (C3)	58
Unit 4		
Radiation Therapy Practices	1. To locate and identify stock inventory (C2, P3) 2. To practice QC of dose calibrator, fumehood (C3, P3) 3. To prepare and dispense radiopharmaceuticals (C3, P3) 4. To practice QC of radiopharmaceutical (C3, P3) 5. To express procedures to patient and to practice as per regulatory guidelines (C2) 6. To produce radiation exposure records (C3) 7. To write and maintain registers (C3, P3)	43

Learning Strategies, Contact Hours and Out of class engagement:						
Learning Strategies	Contact Hours	Out of class engagement				
Lecture	15	15				
Problem Based Learning (PBL)	30	30				
Case Based Learning (CBL)	30	30				
Clinic	112	112				
Revision	6	6				
Assessment	2	2				
Total	195	195				
Formative:			Summative:			
Quiz			Mid Semester (Practical)			
Viva			Viva			
Clinical assessment (OSCE, OSPE, WBPA)			Log Book			
Clinical Log Book			End Semester Exam: NA			
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	x	x	x
Quiz / Viva	x	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x	x
Any others: WPBA	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine - Kowalsky, Richard J., and Steven W. Falen 2. Nuclear Medicine-The Requisites : Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall					
Additional References	1. Radiopharmaceuticals and Hospital Radiopharmacy Practices - N. Ramamoorthy BRIT 2. Radiation safety in Nuclear Medicine - AERB Mumbai 3. Nuclear Medicine Technology: Procedures and Quick Reference – Pete Shackett					

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine							
Course Title	Non-Imaging Nuclear Medicine Techniques							
Course Code	NMT2405							
Academic Year	Second							
Semester	IV							
Number of Credits	3							
Course Prerequisite	Knowledge of basics of Nuclear Medicine instrumentation, biology and pharmacy							
Course Synopsis	This course aims to provide fundamental knowledge in diagnosis of different diseases by non-imaging nuclear medicine procedures.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Explain application of nuclear in-vitro diagnostics in haematology (C3)							
CO2	Explain the radio microbiology and plasma sampling principles and procedures for in vitro diagnostics (C3)							
CO3	Explain working and application of different probes in vitro diagnostic procedures (C3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Nuclear Haematology	The dilution principle: 1. Explain Blood constituents (C2) 2. Define the dilution principle(C1) 3. Explain the principle of blood volume measurement (C2) 4. Demonstrate measurement of Red blood volume(C3) 5. Use various radionuclides and blood elements labelling(C4) 6. Analyze the measurement of plasma volume.(C4) 7. Apply random labelling of leucocytes and platelet labelling (C3) 8. Apply the dilution principle to find the whole blood volume (C4)	11

Content	Competencies	Number of Hours
	9. Determination of erythrocyte life span (C4)	
	Vitamin B12 Deficiency 1. Explain vitamin B12 metabolism in the body and Signs and Symptoms of Vitamin deficiency (C2) 2. Summarize on absorption, transport and storage of vitamin B12 in the body (C3). 3. Explain physical properties of the radionuclides used for Schilling test (C2) 4. Demonstrate vitamin B12 absorption by Schilling test (C3).	6
	Ferrokinesis studies/Iron metabolism : 1. Explain iron metabolism in the body (C2) 2. Explain the production of Fe-59 – Various types, Principle. 3. Demonstrate in details the patient preparation and the procedure protocol for Plasma iron clearance (C3) 4. Demonstrate the Plasma iron turnover rate (PITR) and its utilization (C3) 5. Explain on Absorbed Radiation dose from Fe-59 (C2)	7
	Gastrointestinal blood loss study using Cr51: 1. What is gastrointestinal bleeding? (C1) 2. List the types and symptoms of GIB (C1) 3. Explain management of GIB (C2) 4. Demonstrate the measurement of intestinal blood loss (C3) Splenic sequestration studies 1. What does splenic sequestration mean? (C1) 2. Demonstrate the Spleen sequestration studies (C3)	6
Unit 2		
Radio-respirometry and Plasma Sampling techniques	C14 Urea Breath Test : 1. Describe anatomy and physiology of stomach (C1) 2. List the life threatening GIT disease (C1) 3. Explain the H-pylori (C2) 4. Explain the principle and procedure of radio-respirometry in C14 Urea Breath Test (C3) 5. Extend radio-respirometry in the clinical applications. (C2) Glomerular filtration rate: 1. Describe anatomy and physiology of kidney (C1) 2. Explain various method of kidney function test (C2) 3. Explain methods to determine Glomerular Filtration Rate using Single-Plasma Sample Method (C2)	8

Content	Competencies	Number of Hours
Unit -3		
Radiation Counting Probes	Probes and their applications 1. What is probe? (C1) 2. Explain the types and properties of probes (C2) 3. Explain the applications of different types of probes (C2) 4. Describe the design and working of sentinel node detection probe (C2) 5. Describe the design and working of thyroid uptake probe (C2) 6. Interpret measurements from thyroid uptake probe (C2) 7. Describe the perchlorate discharge test (C3)	7

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	25
Seminar	13	13
Revision	-	2
Assessment	2	5
Total	45	45

Assessment Methods:

Formative:	Summative:
Unit Test	Mid Semester Exam
Assignments/Presentations	End Semester Exam

Mapping of Assessment with COs:

Nature of Assessment	CO1	CO2	CO3
Mid Semester Examination	x	x	-
Quiz / Viva/ Unit Test	x	x	x
Assignments/Presentations	x	x	x
End Semester Exam	x	x	x

Feedback Process:	Mid-Semester Feedback
	End-Semester Feedback
Main Reference:	1. Nuclear Medicine Technology & Techniques by Donald Bernier et.al 2. Radiopharmaceutical in Nuclear Medicine Practice by <i>Richard J. Kowalsky</i> 3. Nuclear Haematology by Johan S. Masjhur
Additional References	1. Text book of Nuclear Medicine basic science Vol-1 by Antonio Da Rocha 2. Nuclear Medicine by Robert E. Henkin, Mark A. Boles

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Radio- Immunology						
Course Code		NMT2406						
Academic Year		Second						
Semester		IV						
Number of Credits		3						
Course Prerequisite		Knowledge of basics of immunology, radiochemistry, radiation physics and Nuclear Medicine instrumentation						
Course Synopsis		This course aims to enhance students' understanding of immune biology and its growing role in disease diagnosis and therapy in Nuclear Medicine						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Relate basic concepts of immunology to its application in immunotherapy (C2)							
CO2	Explain development process of radiolabelled antibodies Understand regulatory aspects pertaining to development process and use for clinical applications (C2)							
CO3	Summarize various in vitro and in vivo applications of radiolabelled antibodies (C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2	x						x	
CO3	x							

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Basic Immunology and Immunobiology	1. What are the components of the immune system?(C1) 2. Distinguish between innate and adaptive immunity (C2) 3. Describe immune cells that regulate and mediate immune response (C1) 4. Explain recognition and effector mechanisms of immune cells (C2) 5. Describe antibody engineering methods 6. Explain antigen antibody interactions (C2) 7. What are applications of immunology in research and clinics? (C1)	10

Content	Competencies	Number of Hours
	8. Explain antibody-based molecular imaging and theranostic strategies (C2)	
Unit 2		
Radio-labeled antibodies	1. Explain radio-labelling strategies, procedure and quality control techniques (C2) 2. Outline regulatory aspects in product development and use (C2)	7
Unit 3		
Radio-immuno diagnostics and therapy	1. Radio-immuno assay (RIA) (C2) a) Explain principle of RIA b) Describe the reagents and assay set up c) Explain statistics, data processing and quality control	7
	2. Immuno Radiometric Assay (IRMA) (C2) a) Explain principle of IRMA b) Describe the reagents and assay set up c) Explain statistics, data processing and quality control	7
	3. Outline the regulatory requirement for set and operation of in vitro radioisotope laboratory (C2)	
	4. Radio-immuno Scintigraphy (C2): Describe the chemical, biological properties, radiolabelling methods and diagnostic use of approved radiolabelled labeled antibodies (99mTc-anti CEA, In-111 satumomab)	7
	5. Radio-Immuno therapy (C2): Describe the structural, chemical, biological, radiol-abeling methods properties and therapeutic use of approved radio-labelled antibodies (Y-90 Zevalin, I131-Bexxar)	7

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	30
Seminar	13	13
Assessment	2	2
Total	45	45
Assessment Methods:		
Formative:	Summative:	
Unit Test	Mid Semester Exam	
Assignments/Presentations	End Semester Exam	

Mapping of Assessment with COs:			
Nature of Assessment	CO1	CO2	CO3
Mid Semester Examination	x	x	-
Quiz / Viva/ Unit Test	x	x	x
Assignments/Presentations	x	x	x
End Semester Exam	x	x	x
Feedback Process:	Mid-Semester Feedback		
	End-Semester Feedback		
Main Reference:	1. Radioimmuno assay- Principles and Practice, Pillai & Bhandarkar 2. Immunology, Kuby 3. Nuclear Medicine – The Requisites Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall		
Additional References	1. Text book of Nuclear Medicine basic science Vol-1 by Antonio Da Rocha 2. Nuclear Medicine by Robert E. Henkin, Mark A. Boles		

SEMESTER - V

Course code	:	Course Title
NMT3301	:	Radiopharmacy in Nuclear Medicine
NMT3302	:	Therapeutic Nuclear Medicine
NMT3303	:	Clinical Nuclear Medicine - I
NMT3304	:	Practicum - V
NMT3305	:	Clinical Practice
*** **	:	Open Elective - II

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine
Course Title	Radiopharmacy in Nuclear Medicine
Course Code	NMT3301
Academic Year	Third
Semester	V
Number of Credits	4
Course Prerequisite	Students should have basic knowledge of radionuclide production methods, radionuclide generators and general radiation safety guidelines related to safe handling of radiopharmaceuticals.
Course Synopsis	This course aims to provide a comprehensive knowledge on development process for new radiopharmaceuticals, clinical application and safe handling of existing diagnostic PET, therapeutic and theranostic radio-pharmaceuticals, particularly focusing on production, radiochemistry, and regulatory aspects.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Explain and apply radio-iodination chemistry and methods for the synthesis of Iodine labelled radiopharmaceuticals(C2)
CO2	Explain PET radiopharmaceutical synthesis methods and ideal radiopharmaceutical's properties for clinical use(C2)
CO3	Identify clinically useful therapeutic and theranostic radiopharmaceuticals and understand their biological interactions (C2)
CO4	Understand regulatory guidelines for development, procurement, safe handling and disposal of radiopharmaceuticals and radioactive material (C2)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2		x					x	
CO3	x						x	
CO4		x		x				

Course Content and Outcomes

Content	Competencies	Number of Hours
Unit 1		
Iodine labelled radiopharmaceuticals	1. Explain radio Iodine Chemistry (C2) 2. Describe the production, physical and chemical characteristics, biological behaviour of different isotopes of Iodine (C2)	11

Content	Competencies	Number of Hours
	3. Compare and identify merits and demerits of various radio-iodination methods (C3) 4. Describe synthesis, quality control and clinical applications of Iodine labelled radiopharmaceuticals (C2)	
Unit 2		
Radiopharmaceuticals for Positron emission tomography (PET)	1. Describe the production of PET radionuclides (C2) 2. Describe the preparation method and quality control procedure for PET radiopharmaceuticals (F-18, C-11, N-13, O-16, Ga-68) (C2) 3. Explain the clinical application and uptake mechanism (C2) 4. Outline the design, working and application of automated synthesis Modules (C2) 5. Outline the design and working of PET Radionuclide generators (C2) 6. Describe safe handling procedures of positron emitters (C2)	17
Unit 3		
Therapeutic and theranostic Radiopharmaceuticals	1. Illustrate targeted Radionuclide therapy and theranostics in nuclear medicine (C2) 2. Interpret the physical, chemical and biological characteristics of Therapeutic and theranostic radionuclides (C2) 3. Explain the therapeutic/theranostic clinical role and biological action mechanism of radio-pharmaceuticals (C2)	14
Unit 4		
Regulatory guidelines for development of Radiopharmaceuticals	1. Extend on general consideration for design of newer radiopharmaceuticals (C2) 2. Describe the development stages and drug terminology used in radio-pharmaceutical development process (C2) 3. Summarize pharmacopeia for radiopharmaceuticals (C2) 4. Extend on Good Hospital Radio pharmacy Practices (GHRP) and Good Manufacturing Practices (GMP) for Radiopharmaceuticals (C2) 5. Outline the relationship between GMP & ISO-relevant to nuclear medicine laboratory (C2)	18

Content	Competencies	Number of Hours
Unit 5		
Regulatory guidelines for procurement, Safe handling and disposal of radioactive material	1. Outline the E- Licensing procedures for handling Radioactive materials in India(C2) 2. Extend on regulation ethics and registration of radiopharmaceuticals(C2) 3. Summarize the procedure and documentations for ordering, receiving, storage, decay and disposal of Radiopharmaceuticals (C2)	

Learning Strategies, Contact Hours and Out of class engagement:				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	45	40		
Seminar	10	10		
Revision	02	5		
Assessment	03	5		
Total	60	60		
Formative:		Summative:		
Unit test		Mid Semester		
Assignment/seminars		End semester		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	-	-
Quiz / Viva/ Unit Test/ Assignment/Seminars	x	x	x	x
End Semester Exam	x	x	x	x
Feedback Process:	Mid-Semester Feedback			
	End-Semester Feedback			
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and 2. Nuclear Medicine, 2 nd American Pharmacists Association, 2004, ISBN 1582120315 Kowalsky, Richard J., and Steven W. Falen, 3. Fundamentals of Nuclear Pharmacy, 3 rd Edition Gopal B Saha			
Additional References	1. Sampson's Text Book of Radiopharmacy 4th Ed (Dec 2010), ISBN : 9780853697893 Edited by Theobald Tony 2. Hand Book of Radiopharmaceuticals by M H Patel			

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Therapeutic Nuclear Medicine
Course Code	NMT3302
Academic Year	Third
Semester	V
Number of Credits	3
Course Prerequisite	Students should have basic knowledge of basic science subjects, Radio-pharmacy, nuclear medicine instrumentation and physics.
Course Synopsis	This course will help the student to learn about therapeutic radiopharmaceuticals, patient preparation, radiation protection and therapy delivery. It also leads to future directions.

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Acquire sound scientific evidence based knowledge of Therapeutic radiopharmaceuticals (C2)
CO2	Demonstrate and possess skills for pre and post radionuclide therapy management (C3)
CO3	Exhibit lifelong learning attitude and ethical team work (C2)
CO4	Exhibit problem solving capabilities (C2)
CO5	Develop good social communication skills to aid in patient management (C2)
CO6	Help create a sound stable foundation for research in therapeutic radiopharmacy. (C3)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2	x	x						
CO3			x				x	
CO4	x	x						
CO5	x				x			
CO6	x						x	

Course Content and Outcomes

Contents	Competencies	Number of Hours
Unit 1		
Basics of Radionuclide therapy	Topic 1 - General principles of Radionuclide therapy 1. What are the physical and chemical	5

Contents	Competencies	Number of Hours
	characteristics of therapeutic radionuclides? (C1) 2. Relate interaction of therapeutic radionuclide with matter/ body/ disease (C2) 3. Recall radiation safety in radionuclide therapy (C1) 4. Explain routes of radionuclide therapy (C2) 5. Extend the effects of radionuclide therapy (C2)	
	Topic 2 : Review of therapeutic radiopharmaceuticals 1. List the various therapeutic radiopharmaceuticals (C1) 2. Explain the pharmacokinetics and dynamics of therapeutic radiopharmaceuticals (C2)	4
Unit 2		
Radionuclide therapy in Benign disorders	Topic 1 :Graves disease/ Toxic adenoma/ Toxic Multinodular goitre 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceutical used (C1) 3. For radioiodine therapy explain mechanism of action, patient preparation and education, dosimetry, radiation safety management. (C2)	3
	Topic 2: Radiosynovectomy 1. Outline in brief pathophysiology of the disease process. (C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management.(C2)	3
	Topic 3: Keloid therapy 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management.(C2)	2
Unit 3		
Radionuclide therapy in Malignant disorders	Topic 1: Bone Pain Palliation 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and	3

Contents	Competencies	Number of Hours
	selection of radionuclides patient preparation and education, radiation safety management. (C2)	
	<p>Topic 2: Phosphorus-32 therapy in polycythemia rubra vera</p> <ol style="list-style-type: none"> 1. Outline in brief pathophysiology of the disease process.(C2) 2. For treatment explain mechanism of action, radiopharmaceutical preparation, patient preparation and education, radiation safety management. (C2) 	1
	<p>Topic 3: Radionuclide therapy in Liver cancer</p> <ol style="list-style-type: none"> 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C2) 	2
	<p>Topic 4: Radioimmunotherapy</p> <ol style="list-style-type: none"> 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C3) 	2
	<p>Topic 5: Radionuclide therapy in malignant peritoneal ascites</p> <ol style="list-style-type: none"> 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C3) 	3
	<p>Topic 6: Radionuclide therapy in Neuroendocrine tumors</p> <ol style="list-style-type: none"> 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C3) 	4

Contents	Competencies	Number of Hours
	Topic 7: Radionuclide therapy in brain tumors 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C2)	3
	Topic 8: Epidermal Radionuclide Therapy 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C2)	4
	Topic 9: Radionuclide therapy for thyroid cancer 1. Outline in brief pathophysiology of the disease process.(C2) 2. List the radiopharmaceuticals used. (C1) 3. For treatment explain mechanism of action, radiopharmaceutical preparation, comparison and selection of radionuclides, patient preparation and education, radiation safety management. (C2)	2
	Topic 10: PET/CT for Radiotherapy Planning 1. Explain the role of PET/CT in tumour assessment/ disease staging and Radiotherapy planning. (C2) 2. Learn about patient setup & scan acquisition and quantitative image analysis (C2)	4

Learning Strategies, Contact Hours and Out of class engagement:		
Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	25
Seminar	3	3
Small group discussion (SGD)	2	2
Self-directed learning (SDL)	2	2
Problem Based Learning (PBL)	2	2
Case Based Learning (CBL)	2	2
Revision	2	4
Assessment	2	5
Total	45	45

Assessment Methods:								
Formative:			Summative:					
Unit Test			Mid Semester Exam (Theory)					
Quiz			End Semester Exam (Theory)					
Viva								
Assignments/Presentations								
Mapping of Assessment with COs:								
Nature of Assessment			CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination			x	x	x	x	x	x
Quiz / Viva/ Unit Test			x	x	x	x	x	x
Assignments/Presentations			x	x	x	x	x	x
End Semester Exam			x	x	x	x	x	x
Feedback Process:		Mid-Semester Feedback						
		End-Semester Feedback						
Main Reference:		1. Nuclear Medicine The Requisites: Thrall James						
		2. Principles and Practice of Nuclear Medicine: P J Early, D.B Sodee						
Additional References		1. Nuclear Medicine in clinical diagnosis and treatment: Peter J Ell						
		2. Principles of Nuclear Medicine: Henry N.Wagner						
		3. Nuclear Medicine: Robert E.Henkin						

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Clinical Nuclear Medicine - I						
Course Code		NMT3303						
Academic Year		Third						
Semester		V						
Number of Credits		4						
Course Prerequisite		Students should have basic knowledge of human anatomy, physiology, nuclear medicine imaging equipment, radio-pharmacy, radiation handling procedures and radiation dosimetry						
Course Synopsis		The course aims to provide understanding of disease pathophysiology, clinical features of diseases, Clinical indication and appropriate use of radiopharmaceuticals for various disease diagnosis, patient preparation, image acquisition, processing, analysis and interpretation.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand the pathological basis of various diseases (C2)							
CO2	Relate and identify the type of nuclear medicine scan indicated, use of appropriate radiopharmaceuticals and patient care procedures (C2)							
CO3	Understand the acquisition and processing of scanning procedures using gamma camera, SPECT/CT and PET/CT (C2)							
CO4	Analyze and interpret scintigraphy scans(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2	x	x						
CO3		x	x					
CO4		x					x	

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Endocrine System	1. Recall important anatomical and physiological features of the system (C1) 2. Describe pathophysiology of thyroid and parathyroid gland disorders (C2) 3. Elaborate on Thyroid imaging (C2) a) Dynamic and static thyroid scan b) Radiopharmaceuticals	14

Content	Competencies	Number of Hours
	c) Imaging protocol/s, d) processing and scan interpretation 4. Elaborate on Thyroid uptake (C2) a) Radiopharmaceutical b) Procedure and calculation, c) Interpretation of uptake value 5. Elaborate on Parathyroid imaging (C2) a) Dual phase, dual isotope technique b) Radiopharmaceuticals c) Imaging protocol/s, d) processing and scan interpretation	
Unit 2		
Skeletal System	1. Recall important anatomical and physiological features of the system (C1) 2. Describe the skeletal tissue damage and systemic response bone remodeling process (C2) 3. Describe the general features of Infection and inflammation and acute and chronic inflammation (C2) 4. Describe the pathophysiology of bone metastatic tumors (C2) 5. Describe the pathophysiology of metabolic bone diseases (C2) 6. Describe the pathophysiology of bone metastatic tumors (C2) 7. Describe the pathophysiology of osteomyelitis (C2) 8. Elaborate on radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis for (C2) a) Whole body bone scan b) 3 phase bone scan c) Infection imaging	17
Unit 3		
Gastrointestinal System	1. Recall important anatomical and physiological features of the system (C1) 2. Describe pathophysiology of oesophageal (C2) 3. Describe pathophysiology of gastric disorders (C2) 4. Elaborate on radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis for (C2) a) oesophageal transit, b) gastro- oesophageal reflux, c) gastric emptying and motility 5. Describe the pathophysiology of intestinal disorders (C2) 6. Elaborate on radiopharmaceuticals Imaging protocol/s, processing and scan interpretation for (C2)	17

Content	Competencies	Number of Hours
	a) Meckel's diverticulum, b) Gastrointestinal bleed 7. Describe the pathophysiology of liver and spleen disorders (C2) 8. Elaborate on radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis for liver and spleen (C2) a) structural b) functional imaging	
Unit 4		
Respiratory System	1. Recall important anatomical and physiological features of the system (C2) 2. Describe the pathophysiology obstructive pulmonary disease (C2) 3. Describe the pathophysiology of Pulmonary embolism and Ventilation perfusion mismatch (C2) 4. Describe the pathophysiology of right to left cardiac shunt (C2) 5. Elaborate on radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis (C2) a) lung ventilation b) lung perfusion imaging, c) right to left cardiac shunt imaging	12

Learning Strategies, Contact Hours and Out of class engagement:				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	45	40		
Seminar	10	10		
Revision	02	05		
Assessment	03	05		
Total	60	60		
Formative:		Summative:		
Unit test		Mid Semester		
Assignment/seminars		End semester		
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	x	-
Quiz / Viva/ Unit Test	x	x	x	x
End Semester Exam	x	x	x	x
Feedback Process:	Mid-Semester Feedback			
	End-Semester Feedback			

Main Reference:	<ol style="list-style-type: none">1. Robbins & Cotran Pathologic Basis of Disease, 9e, Elsevier – 20132. Nuclear Medicine – The Requisites Harvey A. Ziessman Janis P. O'Malley James H. Thrall
Additional References	<ol style="list-style-type: none">1. Nuclear medicine technology and techniques Donald Bernier2. Mosby's Manual of Nuclear Medicine procedures D. Bruce Sodee

Manipal College of Health Professions	
Name of the Department	Department of Nuclear Medicine
Name of the Program	Bachelor of Science in Nuclear Medicine Technology
Course Title	Practicum - V
Course Code	NMT3304
Academic Year	Third
Semester	V
Number of Credits	3
Course Prerequisite	Knowledge of radiopharmacy, safe radiation handling, nuclear medicine physics and instrumentation, diagnostic and therapeutic nuclear medicine
Course Synopsis	<p>This course will impart training in the practical aspects of Radiopharmacy, quality control of tomography and hybrid imaging units and clinical techniques in nuclear medicine department.</p> <p>At the end of the course, the student should be able to apply the knowledge and carry out the practical work in the fields of radiopharmacy and hybrid imaging systems for clinical use in nuclear medicine.</p>

Course Outcomes (COs):
At the end of the course student shall be able to:

CO1	Demonstrate safe handling of therapeutic radioisotopes and administration to the patients (C2, P5)
CO2	Demonstrate quality control and biodistribution for radiopharmaceuticals (C2, P5)
CO3	Organise regulatory documentation and inventory for radiopharmaceuticals (C2, P5)
CO4	Demonstrate practical knowledge of clinical nuclear medicine procedures (C2, P5)

Mapping of Course Outcomes (COs) to Program Outcomes (POs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		x				x		
CO2		x				x		
CO3		x				x		
CO4		x				x		

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Radiopharmaceuticals in Nuclear Medicine	1. To perform elution & interpret elution efficiency of PET Radiotracers from Radionuclide generator (C2) (P5)	27

Content	Competencies	Number of Hours
	<ol style="list-style-type: none"> 2. To demonstrate & interpret quality checks of PET Radiopharmaceuticals (C2) (P5) 3. To demonstrate process for ordering of Radiopharmaceuticals and cold kits (C2) (P5) 4. To demonstrate record keeping of daily elution in Radio pharmacy laboratory (C2) (P5) 5. To demonstrate record keeping of Inventory & stock of cold kits Radioactive materials (C2) (P5) 6. Handling of Radioactive Spillage and contamination (C2) (P5) 7. To demonstrate radiopharmaceutical biodistribution (C2) (P5) 	
Unit 2		
Clinical Nuclear Medicine - I	<ol style="list-style-type: none"> 1. To perform and interpret thyroid scan (C2) (P5) 2. To perform and interpret Parathyroid scan (C2) (P5) 3. To perform and interpret 3 phase/4phase bone scan (C2) (P5) 4. To perform and interpret whole body bone scan (C2) (P5) 5. To perform and interpret bone SPECT/CT (C2) (P5) 6. To perform and interpret gastroesophageal reflux (C2) (P5) 7. To perform and interpret gastric emptying study (C2) (P5) 8. To perform and interpret Meckel's diverticulum (C2) (P5) 9. To perform and interpret GI bleed scan (C2) (P5) 10. To perform and interpret Liver scan (C2) (P5) 11. To perform and interpret spleen scan (C2) (P5) 12. To perform and interpret hepatobiliary studies (C2) (P5) 13. To perform and interpret lung ventilation scan (C2) (P5) 14. To perform and interpret lung perfusion scan (C2) (P5) 15. To perform PET Fusion Imaging (18 F-FDG Scan) in skeleton metastasis (C2) (P5) 	32

Content	Competencies	Number of Hours
	16. To perform PET Fusion Imaging (18 F-FDG Scan) in Hematological malignancies (C2) (P5) 17. To perform PET Fusion Imaging (18 F-FDG Scan) for Prostate Cancer /Bladder Cancer/Renal cell carcinoma (C2) (P5) 18. To perform PET Fusion Imaging (18 F-FDG Scan) for Thyroid Cancer (C2) (P5) 19. To perform PET Fusion Imaging (18 F-FDG Scan) for Neuro endocrine Pancreatic Cancer – metabolic characterization (C2) (P5) 20. To perform PET Fusion Imaging (18 F-FDG Scan) for Hepatocellular Carcinoma/ Spleen Cancer / Liver Cancer (C2) (P5) 21. To perform PET Fusion Imaging (18 F-FDG Scan) of Brain F-18 scan Alzheimer’s disease/ Epilepsy/ Dementia (C2) (P5) 22. To perform PET Fusion Imaging (18 F-FDG Scan) for cardiac PET Scan (C2) (P5) 23. To perform PET Fusion Imaging (18 F-FDG Scan) for Sarcoidosis -Cardiac sarcoidosis and pulmonary sarcoidosis (C2) (P5) 24. To perform PET Fusion Imaging (18 F-FDG Scan) for Lung Cancer diseases (C2) (P5) 25. To Perform PET Fusion Imaging (18 F-FDG scan) for treatment planning & assessment of early therapy response (C2) (P5) 26. To perform PET Fusion Imaging (18 F-FDG Scan) for fever of Unknown origin (C2) (P5) 27. To perform PET Fusion Imaging (18 F-FDG Scan) for oncological malignant imaging (C2) (P5) 28. To perform PET Fusion Imaging (18 F-FDG Scan) for benign Non-oncological imaging (C2) (P5) 29. To perform PET Fusion Imaging (18 F-FDG Scan) for Breast Cancer (C2) (P5)	

Content	Competencies	Number of Hours
Unit 3		
Therapeutic Nuclear Medicine	1. To demonstrate dispensing and oral administration of I-131 (C2) (P5) 2. To demonstrate dispensing and intravenous administration of I-131 MIBG/ Sm-153 (C2) (P5)	06

Learning Strategies, Contact Hours and Out of class engagement:				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	15	15		
Practical	51	51		
Revision	5	5		
Assessment	4	4		
Total	75	75		
Formative:		Summative:		
Unit test	Mid Semester (Practical)			
Quiz	Viva			
Viva	Record book			
Practical Log Book/Record Book	End Semester (Practical)			
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	x	x
Quiz / Viva/ Unit Test	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x
End Semester Exam	x	x	x	x
Feedback Process:	Mid-Semester Feedback			
	End-Semester Feedback			
Main Reference:	1. Nuclear Medicine Technology & Techniques : Donald Bernier et.al 2. Physics in Nuclear Medicine : Sorenson			
Additional References	1. Mosby's Manual of Nuclear Medicine Procedures : D.Brucee Sodee, Paul J early 2. Quality control of Nuclear Medicine instruments : Tecdoc 602 3. Nuclear Medicine – The Requisites : Ziessman et. al			

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Clinical Practice							
Course Code	NMT3305							
Academic Year	Third							
Semester	V							
Number of Credits	3							
Course Prerequisite	Students should have basic knowledge of basic science subjects, radiation physics, Radiopharmacy and nuclear medicine instrumentation.							
Course Synopsis	This course will give training for the candidate to prepare & safely handle the radiopharmaceuticals for clinical applications in Nuclear Medicine department, expose them to the different imaging and non-imaging Nuclear Medicine procedures, to maintain documentations and stock inventory.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand safe handling of radioisotopes and practice radiation safety(C2,P3,A2)							
CO2	Understand the basic applications of Radiopharmacy in clinical nuclear medicine practice(C2,P3,A2)							
CO3	Understand the basic applications of Instrumentation in clinical nuclear medicine practice.(C2,P3,A2)							
CO4	Understand different imaging and non-imaging Nuclear Medicine procedures (C2,P3,A2)							
CO5	To maintain documentations and stock inventory (C1,P1,A2)							
CO6	Learn the importance of effective communication, team work, ethical values and professionalism(C2,P1,A2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x				x			
CO2	x	x						
CO3		x					x	
CO4		x		x				
CO5	x	x						
CO6			x		x			

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Radiopharmacy Practices	1. To arrange Radiopharmacy lab for daily activities (C1,P3) 2. To identify and produce the inventory (C2,P3) 3. To practice QC of dose calibrator (C3,P3) 4. To prepare and dispense radiopharmaceuticals (C3,P3) 5. To practice QC of radiopharmaceutical (C3,P3) 6. To express procedures to patient and to practice as per regulatory guidelines (C2,P3) 7. To write and maintain registers (C3,P3)	34
Unit 2		
In-vitro Nuclear Medicine Practices	1. To locate and identify stock inventory (C2,P3) 2. To operate various non-imaging and radiation monitoring equipments (C3,P3) 3. To produce, analyze and comment on QA reports of all devices in Nuclear Medicine (C3,P3) 4. To produce radiation surveillance reports (C3,P3) 5. To write and maintain registers (C3,P3)	21
Unit 3		
Scintigraphy Practices	1. To arrange imaging room for daily activities (C1,P2) 2. To practice daily QC of imaging and other accessory devices (C3,P3) 3. To express procedures to patient and to practice as per regulatory guidelines (C2,P3) 4. To practice scans and processing techniques (C3,P3) 5. To write and maintain registers (C3)	28
Unit 4		
Radiation Therapy Practices	1. To locate and identify stock inventory (C2,P3) 2. To practice QC of dose calibrator (C3,P3) 3. To prepare and dispense radiopharmaceuticals (C3,P3) 4. To practice QC of radiopharmaceutical (C3,P3) 5. To express procedures to patient and to practice as per regulatory guidelines (C2,P3) 6. To produce radiation exposure records (C3) 7. To write and maintain registers (C3,P3)	22

Learning Strategies, Contact Hours and Out of class engagement:						
Learning Strategies	Contact Hours	Out of class engagement				
Lecture	15	10				
Problem Based Learning (PBL)	15	15				
Case Based Learning (CBL)	15	15				
Clinic	49	49				
Revision	6	11				
Assessment	5	5				
Total	105	105				
Formative:			Summative:			
Quiz			Mid Semester (Practical)			
Viva			Viva			
Clinical assessment (OSCE, OSPE, WBPA)			Log Book			
Clinical Log Book/ Record Book			End Semester Exam: NA			
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	x	x	x
Quiz / Viva	x	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x	x
Any others: WPBA	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine - Kowalsky, Richard J., and Steven W. Falen					
	2. Nuclear Medicine-The Requisites : Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall					
Additional References	3. Radiopharmaceuticals and Hospital Radiopharmacy Practices - N. Ramamoorthy BRIT					
	4. Radiation safety in Nuclear Medicine - AERB Mumbai					
	5. Nuclear Medicine Technology: Procedures and Quick Reference - Pete Shackett					

SEMESTER - VI

Course code	:	Course Title
NMT3401	:	Tomography and Hybrid Imaging
NMT3402	:	Clinical Nuclear Medicine - II
NMT3403	:	Practicum - VI
NMT3404	:	Clinical Practice
NMT****	:	Program Elective - II

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Tomography and Hybrid Imaging						
Course Code		NMT3401						
Academic Year		Third						
Semester		VI						
Number of Credits		4						
Course Prerequisite		Student should have a basic understanding of Nuclear Medicine Instrumentation, Basic mathematics and Radiopharmaceuticals						
Course Synopsis		The course aims to provide understanding on application mathematics and statistics in nuclear medicine. The course also aims to introduce students to imaging modalities like x-ray CT, MRI, SPECT, PET and hybrid imaging.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	The application of basic mathematics in various aspects of Nuclear Medicine (C3)							
CO2	The application of counting statistics in various aspects of Nuclear Medicine (C3)							
CO3	Understand working and instrumentation details of X-ray computed tomography and Magnetic resonance imaging(C2)							
CO4	Understand working and instrumentation details of Single photon emission tomography(C2)							
CO5	Understand working and instrumentation details of Positron emission tomography(C2)							
CO6	Understand working and instrumentation details of Hybrid imaging systems in Nuclear medicine(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						
CO3	x	x						
CO4	x	x						
CO5	x	x						
CO6	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Mathematics in Instrumentation	<ol style="list-style-type: none"> 1. Explain the use of mathematics in Instrumentation in Nuclear Medicine (C2) 2. Apply Vectors in instrumentation in Nuclear Medicine(C3) 3. Apply Matrices in instrumentation in Nuclear Medicine 4. Apply Determinants in instrumentation in Nuclear Medicine (C3) 5. Explain the Interpolation and apply its use in instrumentations (C2 & C3). 6. Transformation and apply its use in instrumentations (C2 & C3). 7. Explain uptake Calculation(C2) What is Calibration factors and calculations (C1)	10
Mathematics in image reconstruction	<ol style="list-style-type: none"> 1. What is Fourier Transformation (C1) 2. Explain Fourier Transformation use in Image Reconstruction. (C2 & C3) 3. What is Laplace Transformation Z transformation.(C1) 4. Explain and apply the Interpolation in image reconstruction. (C2 & C3) 5. Explain Attenuation correction using radon transformation in Nuclear Medicine (C2) Explain and Solve Iterative reconstructions (C2 & C3)	8
Introduction Biostatistics	<ol style="list-style-type: none"> 1. Explain Central tendency, dispersion and types of distributions (C2) 2. Explain Probability distribution (C2) 	2
Counting Errors:	<ol style="list-style-type: none"> 1. Explain types of errors (C2) 2. Explain the measuring errors (C2) 3. Explain Type I error and Type II error. (C2) 	5
Propagational errors:	<ol style="list-style-type: none"> 1. Define and demonstrate propagation errors and used as sums and differences. (C1 & C3) 2. Explain propagation error used as products and ratios (C2) and demonstrate complicated combination (C3) 3. Application of propagation error in effects of average, counting rates.(C3) 4. Demonstrate the errors in effects of background, MDA (C3) and compare counting system in Nuclear Medicine (C4) 5. Analyse the optimization of Time, Counting error in Image (C4) 	9

Content	Competencies	Number of Hours
	6. Uncertainty calculation in all the nuclear medicine experiments.(C3) 7. Apply statistical tests in counting statistics (C3)	
Unit 2		
Computed Tomography and Magnetic Resonance Imaging	1. Introduction to computed tomography (C2) 2. Generations of X-ray CT (C2) 3. Design and working principle of CT (C2) 4. Components of CT (C2), Reconstruction techniques (C2), Performance characteristics and quality control aspects (C2) 5. Introduction to MRI (C2) 6. Design and working principle of MRI (C2) 7. Components of MRI (C2), 8. Reconstruction techniques (C2), 9. Performance characteristics and quality control aspects (C2)	8
Unit 3		
Single Photon Emission Tomography	1. Introduction to SPECT (C2) 2. Design and working principle (C2) 3. Components of SPECT (C2) 4. Data acquisition (C2) 5. Performance characteristics (C2), quality control aspects (C2) 6. SPECT artifacts (C2)	8
Unit 4		
Positron Emission Tomography	1. Introduction to PET (C2), 2. Design, working principle (C2) 3. Components of PET (C2) 4. Data acquisition (C2) 5. Performance characteristics (C2), quality control (C2) 6. Artifacts (C2)	8
Unit 5		
Hybrid Imaging Devices	1. Principle of modality co-registration SPECT-CT, PET-CT, PET-MR (C2) 2. Co-registration of images (C2)	2

Learning Strategies, Contact Hours and Out of class engagement:

Learning Strategies	Contact Hours	Out of class engagement
Lecture	45	40
Seminar	13	15
Assessment	2	5
Total	60	60

Assessment Methods:						
Formative:			Summative:			
Unit Test			Mid Semester Exam			
Assignments/Presentations			End Semester Exam			
Mapping of Assessment with COs:						
Note: Map how each of the COs are assessed (e.g. indicate with a cross)						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	X	-	X	X	-	-
Quiz / Viva/Unit test	X	X	X	X	X	X
Assignments/Presentations	X	X	X	X	-	-
End Semester Exam	X	X	X	X	X	X
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	<ol style="list-style-type: none"> 1. Physics in Nuclear Medicine by Sorenson 2. Text Book of Mathematics by Grawel B.S. 					
Additional References	<ol style="list-style-type: none"> 1. Nuclear Medicine by Robert E. Henkin, Mark A. Boles 2. Mosby's Manual of Nuclear Medicine Procedures by D.Brucee Sodee, Paul J Early 3. Medical Imaging Physics by William R.Hendee, Russell Ritenour 4. Nuclear Medicine Physics by Ramesh Chandra 					

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Clinical Nuclear Medicine - II							
Course Code	NMT3402							
Academic Year	Third							
Semester	VI							
Number of Credits	4							
Course Prerequisite	Students should have basic knowledge of human anatomy, physiology, nuclear medicine imaging equipment, radio-pharmacy, radiation handling procedures and radiation dosimetry							
Course Synopsis	The course aims to provide understanding of disease pathophysiology, clinical features of diseases, Clinical indication and appropriate use of radiopharmaceuticals for various disease diagnosis, patient preparation, image acquisition, processing, analysis and interpretation.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand the pathological basis of various diseases (C2)							
CO2	Relate and identify the type of nuclear medicine scan indicated, use of appropriate radiopharmaceuticals and patient care procedures (C3)							
CO3	Understand the acquisition and processing of scanning procedures using gamma camera, SPECT/CT and PET/CT (C3)							
CO4	Analyse and interpret scintigraphy scans (C3)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x						x	
CO2	x	x						
CO3		x	x					
CO4		x					x	

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Cardiovascular System	1. Recall important anatomical and physiological features of the system (C1) 2. Describe pathophysiology of cardiovascular disorders (C2) 3. Elaborate on Myocardial perfusion scintigraphy (C3) a) Stress and rest scans Imaging procedures b) Radiopharmaceuticals c) Image processing d) scan interpretation	15

Content	Competencies	Number of Hours
	4. Elaborate on multi-gated acquisition, radionuclide ventriculography (C3) a) Radiopharmaceuticals b) Procedure for calculation of ejection fraction and first pass extraction c) Image processing d) Interpretation and quantitative analysis	
Unit 2		
Genitourinary System:	1. Recall important anatomical and physiological features of the system (C1) 2. Describe the pathophysiology of hydronephrosis, tubular obstruction, renovascular hypertension, vesico-uretral reflux (C2) 3. Elaborate on renal dynamic imaging Renogram, diuretic renogram, Captopril renogram study (C3) a) Radiopharmaceutical b) Procedure c) Time activity curve characteristics d) Image processing e) Interpretation and quantitative analysis 4. Elaborate on renal cortical imaging study (C3) a) Radiopharmaceuticals b) Procedure c) Interpretation 5. Describe vesicoureteral reflux (VUR) study (C3) a) Radiopharmaceuticals b) Protocol for direct and indirect VUR scan c) Image processing d) Interpretation and quantitative analysis	14
Unit 3		
Central Nervous System	1. Recall important anatomical and physiological features of the system (C1) 2. Describe pathophysiology of dementia, epilepsy brain death, hydrocephalus (C2) 3. Elaborate on brain perfusion imaging describing radiopharmaceuticals Imaging protocol/s, processing, scan interpretation (C3)for a) Various forms of dementia b) Epilepsy c) Brain death d) Blood brain barrier integrity e) Brain tumors f) Brain metabolism 4. Elaborate on radionuclide cysternography describing radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis (C3) for	17

Content	Competencies	Number of Hours
	a) Hydrocephalus b) Cerebrospinal fluid (CSF) leak c) CSF shunt patency	
Unit 4		
Miscellaneous Studies	1. Recall important anatomical and physiological features of the immune system system, basic immuno-biology, lymphatic system (C2) 2. Describe the pathophysiology of infection and inflammation in general (C2) 3. Elaborate on radiopharmaceuticals Imaging protocol/s, processing, scan interpretation and quantitative analysis (C3) for a) Non skeletal infection imaging b) Lympho-scintigraphy c) Dacroscintigraphy d) Sialoscintigraphy e) Testicular Scintigraphy f) Immunoscintigraphy	14

Learning Strategies, Contact Hours and Out of class engagement				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	45	40		
Seminar	13	15		
Assessment	2	5		
Total	60	60		
Formative	Summative			
Unit test	Mid Semester			
Assignment/seminars	End semester			
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x	x	x
Quiz / Viva/ Unit Test	x	x	x	x
End Semester Exam	x	x	x	x
Feedback Process:	Mid-Semester Feedback			
	End-Semester Feedback			
Main Reference:	1. Robbins & Cotran Pathologic Basis of Disease, 9e, Elsevier – 2013 2. Nuclear Medicine – The Requisites Harvey A. Ziessman Janis P. O'Malley James H. Thrall			
Additional References	1. Nuclear medicine technology and techniques Donald Bernier 2. Mosby's Manual of Nuclear Medicine procedures D. Bruce Sodee			

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Practicum - VI						
Course Code		NMT3403						
Academic Year		Third						
Semester		VI						
Number of Credits		4						
Course Prerequisite		Knowledge of radiopharmacy, safe radiation handling, nuclear medicine physics and instrumentation, diagnostic and therapeutic nuclear medicine						
Course Synopsis		<p>This course will impart training in the practical aspects of Radiopharmacy, quality control of tomography and hybrid imaging units and clinical techniques in nuclear medicine department.</p> <p>At the end of the course, the student should be able to apply the knowledge and carry out the practical work in the fields of radiopharmacy and hybrid imaging systems for clinical use in nuclear medicine.</p>						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Demonstrate safe handling of therapeutic radioisotopes and administration to the patients (C3, P5)							
CO2	Demonstrate quality control and biodistribution for radiopharmaceuticals (C3, P5)							
CO3	Organize regulatory documentation and inventory for radiopharmaceuticals(C3, P5)							
CO4	Demonstrate practical knowledge of clinical nuclear medicine procedures(C3, P5)							
CO5	Demonstrate and handling the counting system with minimize the error.(C3, P5)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		x				x		
CO2		x				x		
CO3		x				x		
CO4		x				x		
CO5		x					x	

Course Content and Outcomes

Content	Competencies	Number of Hours
Unit 1		
Tomography and hybrid imaging	<ol style="list-style-type: none"> 1. To perform pixel size test (C3,P5) 2. To perform SPECT QC (C3,P5) 3. To perform PET QC (C3,P5) 	15
Unit 2		
Clinical Nuclear Medicine –II	<ol style="list-style-type: none"> 1. To perform Radionuclide ventriculography (C2) (P5) 2. To perform Myocardial perfusion imaging (C2) (P5) 3. To perform Myocardial viability imaging (C2) (P5) 4. To perform Cortical imaging (C2) (P5) 5. To perform Renal dynamic scan/ Transplant evaluation (C2) (P5) 6. To perform DRCG/VCUG (C2) (P5) 7. To perform Radionuclide cisternography (C2) (P5) 8. To perform Ventriculo-peritoneal shunt evaluation (C2) (P5) 9. To perform Dementia imaging (C2) (P5) 10. To perform Infection imaging (C2) (P5) 11. To perform Lymphoscintigraphy (C2) (P5) 12. To perform Dacroscintigraphy (C2) (P5) 13. To perform Sentinal lymphnode imaging (C2) (P5) 14. To perform Sialoscintigraphy (C2) (P5) 	57
Unit 3		
Counting statistics	<ol style="list-style-type: none"> 1. Explain, apply and analyse the effect of background in NM (C3) (P5) 2. Explain, apply and analyse the Counting Rate uncertainty in NM (C3) (P5) 3. Explain, apply and analyse the Comparison of various Counting systems (C3) (P5) 4. Explain, apply and analyse the Minimum detectable activity of the counting instruments (C3) (P5) 5. Demonstrate the pipetting Efficiency using weighing balance (C3) (P5) 6. Explain, apply and analyse the pipetting Efficiency using radioactivity (C4) (P5) 	18

Learning Strategies, Contact Hours and Out of class engagement:					
Learning Strategies	Contact Hours	Out of class engagement			
Lecture	30	30			
Seminar	-	-			
Clinic	-	-			
Practical	60	60			
Revision	0	0			
Assessment	0	-			
Total	90	90			
Formative:		Summative:			
Unit test		Mid Semester (Practical)			
Quiz		Viva			
Viva		Record book			
Practical Log Book/Record Book		End Semester (Practical)			
Mapping of Assessment with COs:					
Nature of Assessment	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	x	x	x	-	-
Quiz / Viva/ Unit Test	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x
End Semester Exam	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback				
	End-Semester Feedback				
Main Reference:	1. Nuclear Medicine Technology & Techniques Donald Bernier et.al				
	2. Physics in Nuclear Medicine Sorenson				
	3. Mosby's Manual of Nuclear Medicine Procedures D.Bruce Sodee, Paul J early				
Additional References	4. Quality control of Nuclear Medicine instruments Tecdoc 602				
	5. Nuclear Medicine - The Requisites-Harvey A. Ziessman Janis P. O'Malley, James H. Thrall				

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Clinical Practice						
Course Code		NMT3404						
Academic Year		Third						
Semester		VI						
Number of Credits		5						
Course Prerequisite		Students should have basic knowledge of basic science subjects, radiation physics, Radiopharmacy and nuclear medicine instrumentation.						
Course Synopsis		This course will give training for the candidate to prepare & safely handle the radiopharmaceuticals for clinical applications in Nuclear Medicine department, expose them to the different imaging and non-imaging Nuclear Medicine procedures, to maintain documentations and stock inventory.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand safe handling of radioisotopes and practice radiation safety(C2,P3,A2)							
CO2	Understand the basic applications of Radiopharmacy in clinical nuclear medicine practice(C2,P3,A2)							
CO3	Understand the basic applications of Instrumentation in clinical nuclear medicine practice.(C2,P3,A2)							
CO4	Understand different imaging and non-imaging Nuclear Medicine procedures (C2,P3,A2)							
CO5	To maintain documentations and stock inventory (C1,P1,A2)							
CO6	Learn the importance of effective communication, team work, ethical values and professionalism(C2,P1,A2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x				x			
CO2	x	x						
CO3		x					x	
CO4				x		x		
CO5	x	x						
CO6			x		x			

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Radiopharmacy Practices	1. To arrange Radiopharmacy lab for daily activities (C1, P2) 2. To identify and produce the inventory (C2,P3) 3. To practice QC of dose calibrator (C3 P3) 4. To prepare and dispense radiopharmaceuticals (C3 P3) 5. To practice QC of radiopharmaceutical (C3 P3) 6. To express procedures to patient and to practice as per regulatory guidelines (C2 P3) 7. To write and maintain registers (C3 P3)	58
Unit 2		
In-vitro Nuclear Medicine Practices	1. To locate and identify stock inventory (C2 P3) 2. To operate various non-imaging and radiation monitoring equipments (C3 P3) 3. To produce, analyze and comment on QA reports of all devices in Nuclear Medicine(C3,P3) 4. To produce radiation surveillance reports (C3,P3) 5. To write and maintain registers (C3,P3)	42
Unit 3		
Scintigraphy Practices	1. To arrange imaging room for daily activities (C1,P2) 2. To practice daily QC of imaging and other accessory devices (C3,P3) 3. To express procedures to patient and to practice as per regulatory guidelines (C2,P3) 4. To practice scans and processing techniques (C3,P3, A2) 5. To write and maintain registers (C3,P3)	53
Unit 4		
Radiation Therapy Practices	1. To locate and identify stock inventory (C2,P3) 2. To practice QC of dose calibrator, fumehood (C3,P3) 3. To prepare and dispense radiopharmaceuticals (C3,P3) 4. To practice QC of radiopharmaceutical (C3,P3) 5. To express procedures to patient and to practice as per regulatory guidelines (C2,P3) 6. To produce radiation exposure records (C3,P3) 7. To write and maintain registers (C3, P3)	42

Learning Strategies, Contact Hours and Out of class engagement:						
Learning Strategies	Contact Hours	Out of class engagement				
Lecture	15	15				
Problem Based Learning (PBL)	30	30				
Case Based Learning (CBL)	30	30				
Clinic	112	106				
Revision	6	6				
Assessment	2	4				
Total	195	195				
Formative:			Summative:			
Quiz			Mid Semester (Practical)			
Viva			Viva			
Clinical assessment (OSCE, OSPE, WBPA)			Log Book			
Clinical Log Book			End Semester Exam: NA			
Mapping of Assessment with COs:						
Nature of Assessment	CO1	CO2	CO3	CO4	CO5	CO6
Mid Semester Examination	x	x	x	x	x	x
Quiz / Viva	x	x	x	x	x	x
Clinical/Practical Log Book/ Record Book	x	x	x	x	x	x
Any others: WPBA	x	x	x	x	x	x
Feedback Process:	Mid-Semester Feedback					
	End-Semester Feedback					
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine - Kowalsky, Richard J., and Steven W. Falen 2. Nuclear Medicine-The Requisites : Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall					
Additional References	1. Radiopharmaceuticals and Hospital Radiopharmacy Practices - N. Ramamoorthy BRIT 2. Radiation safety in Nuclear Medicine - AERB Mumbai 3. Nuclear Medicine Technology: Procedures and Quick Reference – Pete Shackett					

Manipal College of Health Professions								
Name of the Department		Department of Nuclear Medicine						
Name of the Program		Bachelor of Science in Nuclear Medicine Technology						
Course Title		Principles and Techniques in Radiopharmaceutical Development						
Course Code		NMT3405						
Academic Year		Third						
Semester		VI						
Number of Credits		3						
Course Prerequisite		Students should have basic knowledge of radionuclide production methods, radionuclide generators, medical cyclotron, radiolabelling and regulatory guidelines related to handling of radiopharmaceuticals.						
Course Synopsis		This course aims to provide a comprehensive knowledge on advances in radionuclide generator, medical cyclotron for production of radionuclides and ready to use radiopharmaceuticals for nuclear medicine. Students will get the overview of principles, techniques and steps used for development process for newly designed radiopharmaceuticals.						
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Understand & explain advances & developments in radionuclide generators & medical cyclotron production of radionuclides for designing newer radiopharmaceuticals (C2)							
CO2	Explain the various Principles , techniques and methods applied for radiolabelling of PET & Theranostic radiopharmaceuticals(C2)							
CO3	Overview and understanding the principles of various techniques used for characterization of newly designed radiopharmaceuticals (C2)							
CO4	Review of regulatory processes for design & development of newer radiopharmaceuticals and Understanding the methods and techniques used for translational applications.(C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x							
CO2		x						
CO3	x			x				
CO4		x		x				

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Advances & developments in production of radionuclides	Unit 1.1:Advances in Radionuclide generators 1. Describe the working principle and applications of newer radionuclide generators. (C2) 2. Describe various types of automations in new Radionuclide generators (C2) 3. Describe recent developments in design and working of radionuclide generators (Ga-68 and Tc-99m)	09
	Unit 1.2: Advancements in radionuclide production techniques of medical cyclotron 1. Describe advances in cyclotron Target processing and design(C2) 2. Describe Cyclotron Production of ^{99m} Tc (C2)	8
Unit 2		
Radiolabelling Principles and techniques	1. Explain radiolabeling through substitution and coordination reactions (C2). 2. Explain the Radiolabelling chemistry of F-18 labelled pharmaceuticals (C2) 3. Explain the Radiolabelling chemistry of Lu-177 labelled pharmaceuticals (C2)	8
Unit 3		
Principles & Techniques for characterization of newly designed radiopharmaceuticals	1. Explain spectroscopic techniques (FT-IR, Mass spectroscopy, NMR, CD spectroscopy, UV/Vis/NIR spectroscopy) (C2) 2. Explain miscellaneous techniques (PCR, Gel electrophoresis, paper electrophoresis, electron microscopy) (C2)	10
Unit 4		
Design &development of Radiopharmaceuticals	1. Explain the process of drug discovery (in-silico and computational studies) (C2) 2. Explain techniques for preclinical characterization of newer radiopharmaceuticals and translational imaging in humans.(C2)	10

Learning Strategies, Contact Hours and Out of class engagement:				
Learning Strategies	Contact Hours	Out of class engagement		
Lecture	30	30		
Seminar	13	15		
Assessment	2	-		
Total	45	45		
Formative:		Summative:		
Unit test	Mid Semester			
Assignment/seminars	End semester			
Mapping of Assessment with COs:				
Nature of Assessment	CO1	CO2	CO3	CO4
Mid Semester Examination	x	x		-
Quiz / Viva/ Unit Test	x	x	x	x
End Semester Exam	x	x	x	x
Feedback Process:	Mid-Semester Feedback			
	End-Semester Feedback			
Main Reference:	1. Radiopharmaceuticals in Nuclear Medicine Pharmacy and Nuclear Medicine, 2 nd American Pharmacists Association, 2004 ISBN 1582120315 Kowalsky, Richard J., and Steven W. Falen, 2. Fundamentals of Nuclear Pharmacy, 3 rd Edition Gopal B Saha			
Additional References	1. Sampson's Text Book of Radiopharmacy 4th Ed (Dec 2010) ISBN : 9780853697893 Edited by Theobald Tony 2. Hand Book of Radiopharmaceuticals by M H Patel			

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Principles and Techniques in Nuclear Medicine Image Analysis							
Course Code	NMT3406							
Academic Year	Third							
Semester	VI							
Number of Credits	3							
Course Prerequisite	Students should have basic knowledge of nuclear medicine instrumentation physics and nuclear medicine clinical procedures.							
Course Synopsis	This course will help the student to learn about analysis and processing of nuclear medicine images.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Analyse Nuclear Medicine images (C2)							
CO2	Present 2D and 3D Nuclear Medicine images for interpretation (C2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	x	x						
CO2	x	x						

Course Content and Outcomes:

Content	Competencies	Number of Hours
Unit 1		
Nuclear Medicine Image Analysis	1. Image Presentation (C2) 2. Image interpolation (C2) 3. Image display (C2) 4. Image Filtering (C2) 5. Image Segmentation (C2)	15
Unit 2		
Nuclear Medicine Image Quantification	1. Region of Interest Analysis (C2) 2. Quantitative whole body imaging (C2) 3. Activity quantification with conjugate views (C2f)	15
Unit 3		
3 dimensional image display and image registration	1. Surface Rendering (C2) 2. Volume Rendering (C2) 3. Maximum Intensity Projection (C2) 4. Principles of image registration (C2)	15

Learning Strategies, Contact Hours and Out of class engagement:		
Learning Strategies	Contact Hours	Out of class engagement
Lecture	30	25
Seminar	13	15
Revision	2	5
Total	45	45
Assessment Methods:		
Formative:		Summative:
Unit Test	Mid Semester Exam (Theory)	
Quiz	End Semester Exam (Theory)	
Assignments/Presentations		
Mapping of Assessment with COs:		
Nature of Assessment	CO1	CO2
Mid Semester Examination	x	-
Quiz / Viva/ Unit Test	x	x
Assignments/Presentations	x	x
End Semester Exam	x	x
Feedback Process:	Mid-Semester Feedback	
	End-Semester Feedback	
Main Reference:	1. Basic Sciences of Nuclear Medicine: Magdy M.Khalil 2. Quantitative Analysis in Nuclear Medicine Imaging: Habib Zaidi	
Additional References	1. Principles and Practice of Nuclear Medicine: P J Early, D.B Sodee 2. Physics in Nuclear Medicine: Sorenson 3. Nuclear Medicine: Robert E.Henkin	

SEMESTER - VII & VIII

Internship

Manipal College of Health Professions								
Name of the Department	Department of Nuclear Medicine							
Name of the Program	Bachelor of Science in Nuclear Medicine Technology							
Course Title	Internship							
Academic Year	Fourth							
Semester	VII & VIII							
Duration	6+6=12 months (1 year)							
Course Prerequisite	Students should have knowledge of basic science subjects, Radiopharmacy, Nuclear Medicine Instrumentation and physics, Radiation Safe Handling, Nuclear Medicine Procedures, general hospital practice							
Course Synopsis	This course will give training and confidence for the trainees to prepare as well as to safely handle radiopharmaceuticals, perform various Nuclear Medicine diagnostics and therapeutic procedures, perform various quality control procedures, record keeping and stock inventory.							
Course Outcomes (COs):								
At the end of the course student shall be able to:								
CO1	Safely handle radioisotopes, practice radiation safety and regulatory norms (C3,P2,A2)							
CO2	Practice in Radiopharmacy/ hot labs (C2,P3,A3)							
CO3	Perform various quality control checks of equipments, radiopharmaceutical etc. and address trouble shooting (C3,P3,A3)							
CO4	Perform various clinical Nuclear Medicine procedures (C3,P3,A3)							
CO5	Maintain record keeping and stock inventory. Learn the importance of effective communication, team work, ethical values and professionalism(C2,P3,A3)							
CO6	Display entrepreneurship, leadership and mentorship skills to practice independently as well as in collaboration with the interdisciplinary health care team(C2,P3,A2)							
Mapping of Course Outcomes (COs) to Program Outcomes (POs):								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		X				X		
CO2		X	X					
CO3	X	X						
CO4						X	X	
CO5				X	X			
CO6							X	X

Course Content and Outcomes:

Content	Competencies
Area 1:Radiopharmacy Practices	
1. To set Radiopharmacy (SPECT, PET) lab for daily activities (P2) 2. To identify and produce the inventory (A2) 3. To evaluate QC of dose calibrator (A3) 4. To prepare and dispense radiopharmaceuticals (C3) 5. To evaluate QC of radiopharmaceutical (A3) 6. To express procedures to patient and to practice as per regulatory guidelines (C2) 7. Documentation and record keeping (C3)	
Area 2:In-vitro Nuclear Medicine Practices	
1. To locate and identify stock inventory (C2) 2. To evaluate QC of various non-imaging and radiation monitoring equipments (A3) 3. To perform Invitro procedures (C3) 4. To operate various non-imaging and radiation monitoring equipments (C3) 5. To produce radiation surveillance reports (P3) 6. Documentation and record keeping (C3)	
Area 3:Scintigraphy Practices	
1. To set imaging room (SPECT, PET) for daily activities (P2) 2. To practice and evaluate daily QC of imaging (SPECT, PET) and other accessory devices (C3, A3) 3. To take required patient history for the procedure (C2) 4. To express procedures to patient and to practice as per regulatory guidelines (C2) 5. To perform scans and processing techniques (C3, A3) 6. Documentation and record keeping (C3)	
Area 4:Radiation Therapy Practices	
1. To locate and identify stock inventory (C2) 2. To evaluate QC of dose calibrator (A3) 3. To prepare and dispense radiopharmaceuticals (C3) 4. To evaluate QC of radiopharmaceutical (A3) 5. To express procedures to patient and to practice as per regulatory guidelines (C2) 6. To produce radiation exposure records (C3) 7. Documentation and record keeping (C3)	
Area 5 : CT and MRI Practices	
1. To set the imaging room for daily activities(P2) 2. To practice and evaluate daily QC of imaging and other accessory device (C3,A3) 3. To take required patient history for the procedure(C2) 4. To express procedure to patient and to practice as per regulatory guideline(C2) 5. To perform scan and processing techniques (C3, A3) 6. Documentation and record keeping(C3)	

Learning Strategies: Small group discussion (SGD), Problem Based Learning (PBL), Case Based Learning (CBL), Clinics, Seminars

Formative Assessment: Clinical Log Book

Internship completion certificate will be issued from Dean's office, only after

- successfully clearing all four assessment exams and
- obtaining satisfactory completion certificate from the head/ In-charge of the department at the end of internship.

7. Program Outcomes (POs) and Course Outcomes (COs) Mapping

Semester	Course Code	Course Title	Credits	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
I	ANA1303	Anatomy	3	CO1 CO2							
	PHY1301	Physiology -I	2	CO1 CO2 CO3 CO4							
	NMT1301	Fundamentals of Electronics	3	CO1 CO2 CO3	CO3						
	NMT1302	Radiation Physics	4	CO1 CO2 CO3 CO4 CO5 CO6	CO3 CO6						
	NMT1303	Practicum I	4	CO1 CO2 CO3	CO1 CO2 CO3						
	NMT1304	Lab Practice	4	CO1 CO2 CO3 CO4 CO5			CO2				
II	PHY1401	Physiology-II	2	CO1 CO2 CO3 CO4							
	BIC1401	Biochemistry	3	CO1 CO2 CO3 CO4							
	EIC1501	Environmental Science	2	CO1 CO2 CO3		CO4 CO5	CO2		CO1 CO3 CO5	CO4	
		Indian Constitution		CO1		CO3	CO2 CO5	CO2	CO4	CO1 CO3 CO5	CO4
	CSK1501	Communication Skills	2		CO3	CO4		CO1 CO2		CO1 CO2 CO3 CO4	
	NMT1401	Cell and Molecular Biology	4	CO1 CO2 CO3 CO4							
NMT1402	Bioethics and Patient Care	3		CO1 CO3 CO4 CO5	CO6	CO1 CO2 CO3 CO4	CO2 CO5 CO6				

Semester	Course Code	Course Title	Credits	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
	NMT1403	Practicum-II	3	CO1 CO2	CO1 CO2						
	NMT1404	Clinical Practice	1	CO1	CO1 CO2	CO2					
III	NMT2301	Introduction to Radiopharmacy	4	CO1 CO2 CO3 CO4 CO5 CO6	CO3 CO4 CO5 CO6						
	NMT2302	Nuclear Medicine Instrumentation Physics	4	CO1 CO2 CO3 CO4	CO1 CO2 CO3 CO4						
	NMT2303	Mathematics in Nuclear Medicine	3	CO1 CO2 CO3 CO4 CO5 CO6	CO1 CO2 CO3 CO4 CO6				CO5		
	NMT2304	Practicum-III	4	CO1 CO2 CO3 CO4 CO5 CO6 CO7	CO1 CO2 CO3 CO4 CO5 CO6 CO7				CO1 CO3 CO4 CO5 CO6		
	NMT2305	Clinical Practice	2	CO1 CO2 CO5	CO2 CO3 CO4 CO5	CO6	CO4	CO1 CO6		CO3	
	*** **	Open Elective -I	3	open electives credited, choice-based and is graded as satisfactory/not satisfactory(S/NS). Students make a choice from pool of elective offered by MAHE institution/online courses as approved by the department							
IV	BST3401	Biostatistics and Research Methodology	3	CO1 CO2 CO3 CO5 CO6	CO4						
	NMT2401	Radiobiology	3	CO1 CO2 CO3 CO4	CO4					CO1 CO2 CO3	
	NMT2402	Health Physics	3	CO1 CO2 CO3	CO1 CO2 CO3 CO4 CO5	CO4 CO5					

Semester	Course Code	Course Title	Credits	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	
	NMT2403	Practicum-IV	3	CO1	CO2 CO3				CO1 CO2 CO3			
	NMT2404	Clinical Practice	5	CO1 CO2 CO5	CO2 CO3 CO5	CO6	CO4	CO1 CO6	CO4	CO3		
	NMT2405	Non-Imaging Nuclear Medicine Techniques	3	CO1 CO2 CO3	CO1 CO2 CO3							
	NMT2406	Radioimmunology		CO1 CO2 CO3						CO1 CO2		
V	NMT3301	Radiopharmacy in Nuclear Medicine	4	CO1 CO3	CO2 CO4		CO4			CO1 CO2 CO3		
	NMT3302	Therapeutic Nuclear Medicine	3	CO1 CO2 CO4 CO5 CO6	CO2 CO4	CO3		CO5		CO3 CO6		
	NMT3303	Clinical Nuclear Medicine -I	4	CO1 CO2	CO2 CO3 CO4	CO3				CO1 CO4		
	NMT3304	Practicum -V	3		CO1 CO2 CO3 CO4				CO1 CO2 CO3 CO4			
	NMT3305	Clinical Practice	3	CO1 CO2 CO5	CO2 CO3 CO4 CO5	CO6	CO4	CO1 CO6		CO3		
	**** **	Open Elective-II	3	open electives credited, choice-based and is graded as satisfactory/not satisfactory(S/NS). Students make a choice from pool of elective offered by MAHE institution/online courses as approved by the department								
VI	NMT3401	Tomography and Hybrid imaging	4	CO1 CO2 CO3 CO4 CO5 CO6	CO1 CO2 CO3 CO4 CO5 CO6							
	NMT3402	Clinical Nuclear Medicine-II	4	CO1 CO2	CO2 CO3 CO4	CO3				CO1 CO4		
	NMT3403	Practicum-VI	4		CO1 CO2 CO3 CO4 CO5				CO1 CO2 CO3 CO4	CO5		

Semester	Course Code	Course Title	Credits	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
	NMT3404	Clinical Practice	5	CO1 CO2 CO5	CO2 CO3 CO5	CO6	CO4	CO1 CO6	CO4	CO3	
	NMT3405	Principles and Techniques in Radiopharmaceutical Development	3	CO1 CO3	CO2 CO4		CO3 CO4				
	NMT3406	Principles and Techniques in Nuclear Medicine Image Analysis		CO1 CO2	CO1 CO2						
VII & VIII	NA	Internship	(1-year duration)	CO3	CO1 CO2 CO3	CO2	CO5	CO5	CO1 CO4	CO4 CO6	CO6

8. UG Program regulation

1. Program Structure

- 1.1. The program is a choice based credit system.
- 1.2. An academic year consists of two semesters – Odd semester (July - December) and Even semester (January – June).
- 1.3. Each semester shall extend over a minimum period of 16 weeks of academic delivery excluding examination days, semester breaks, declared holidays and extracurricular events.
- 1.4. Medium of instruction shall be in English

2. Credit Distribution

- 2.1 Each semester would consist minimum of 20 credits.
- 2.2 The credit distribution hours for Lecture, Tutorial, Practical, and Clinics are as follows:
 - Lecture / Tutorial: 1 credit = 15 hrs
 - Practical: 1 credit = 30 hours
 - Clinical: 1 credit = 45 hours
- 2.3 A semester has courses structured as theory, practical, laboratory and clinics. Each course is of minimum 2 credits.
- 2.5 Internship duration is as per the course regulation.
- 2.6 Abbreviations / Symbols used in the credit distribution table:
L - Lectures, T - Tutorials, P -Practical, CL - Clinics, C - Total credits, IAC - Internal assessment component, ESE - End-Semester Exam, *Open Elective, #Program Elective

3. Weightage for Internal Assessment Component (IAC) and End Semester Exam (ESE)

- 3.1. Any one or a combination of marks distribution criteria applicable to a course

Program	IAC Weightage (%)	ESE Weightage (%)
RCI Approved Programs	20	80
	25	75
	50	50
	100	Nil
	Nil	100
Other Programs	30	70
	50	50
	100	Nil

- 3.2 The IAC component weightage for theory & practical is:
 - 50% from Mid-semester examination
 - 50% through Continuous assessment (as applicable to course)
- 3.3 For courses without continuous evaluation components, two sessional exams are conducted and the average of both sessional exams shall be considered as the final IAC.

4. Attendance

4.1 Minimum attendance requirements for each course is:

- i. Theory : 75 %
- ii. Clinics / Practical : 85 %

4.2 As per the directives of MAHE, the deemed to be university, there will be no consideration for leave on medical grounds. The student will have to adjust the same in the minimum prescribed attendance. No leverage will be given by the department / institution for any attendance shortage.

4.3 Students requiring leave during the academic session should apply for the same through a formal application to the Head of Department through their respective Class In-charge/ Coordinator. The leave will be considered as absent and reflected in their attendance requirements.

4.4 Students, Parents/ guardians can access the attendance status online (Student Life Cycle Management) periodically.

4.6 Students having attendance shortage in any course (theory & practical) will not be permitted to appear for the End-semester exam (ESE) of the respective course unless the attendance is compensated as per the institutional guidelines.

5. Evaluation / Examination

5.1 The final evaluation for each course shall be based on Internal Assessment Component (IAC) and the End-semester examination (ESE) as per the weightage indicated for respective courses.

5.2 Internal Assessment Component (IAC) shall be estimated based on the performance of the student in mid semester exam or sessional exam/s, and continuous assessment (class participation, assignments, seminars or any other component as applicable to a course).

5.3 For courses such as Communication skills, Open electives, Indian constitution, Environmental sciences or courses as specified in curriculum of respective program, only internal assessment is conducted.

5.4 At the end of each semester, a regular End Semester Examination (ESE) for the odd and even semesters will be conducted in November-December/ May-June cycle respectively.

5.5 A one week of preparatory leave will be given to students before they appear for the regular end semester examination.

5.6 A student should obtain minimum of 40% Internal Assessment Component (IA) to be eligible for End Semester Examination. Failure to secure 40%, he/she will be not appearing for the regular End Semester Examination (ESE). However, he/she will be permitted to write during the supplementary exam as per institutional guidelines.

5.7 The duration of End Semester Examination for a 2 credit course would be 2 hours (50 marks) and for a course with 3 or more credits, 3 hours (100 marks).

5.8 For pre / para clinical course and program elective, irrespective of credit (2 or 3), the ESE is conducted out of 50 and normalized to 100 including internal assessment.

5.9 For those students who failed to earn credit for a course during regular End Semester Examination, an additional supplementary / make up exam is conducted within 2 weeks of declaration of end semester result.

- 5.10 In order to facilitate for improvement of Internal assessment for failed candidates, an internal assessment exam will be conducted immediately after the declaration of end semester (ESE) results. This examination will be conducted as per the university guidelines.
- 5.11 A regular student is eligible to appear for two attempts per cycle of each semester (End semester and supplementary exams).
- 5.12 For a student who has completed the mandated academic requirements / final year, but has pending courses from any of semesters, he / she can take the examination of courses irrespective of odd / even exam cycle. The additional odd / even semester exam as applicable is scheduled between the regular and supplementary exam.

6. Minimum Requirements for Pass

- 6.1 A ten (10) point grading system (**credit value**) is used for awarding a letter grade in each course.

Letter Grade	A+	A	B	C	D	E	F/I/DT
Grade points	10	9	8	7	6	5	0

DT – Detained/Attendance shortage, I – Incomplete

- 6.2. A pass in a ESE will be reflected as grades. Candidate shall be declared to have passed in any course, when he/she obtains not less than “**E**” grade.
- 6.3 However, when a student appears for supplementary examination, the maximum grade awarded is “**C**” grade or below irrespective of their performance.
- 6.4. **Pass criteria for courses with End Semester Examination:** For theory / practical course, a candidate should secure a minimum of 40% in ESE and an overall 50% including IAC to be declared as pass.
- 6.5. **Pass criteria for courses with Internal Assessment Component:** The students should obtain 50% IAC to be declared as pass in a given semester.

7. Calculation of GPA and CGPA

- 7.1. Evaluation and Grading (**Relative Grading**) of students shall be based on GPA (Grade Point Average) & CGPA (Cumulative Grade Point Average).
- 7.2. The overall performance of a student in each semester is indicated by the Grade Point Average (GPA). The overall performance of the student for the entire program is indicated by the Cumulative Grade Point Average (CGPA).
- 7.3. A ten (10) point grading system (**credit value**) is used for awarding a letter grade in each course.

Letter Grade	A+	A	B	C	D	E	F/I/DT
Grade points	10	9	8	7	6	5	0

DT – Detained/Attendance shortage, I – Incomplete

7.4 Calculation of GPA & CGPA: An example is provided

Course code	Course	Credits (a)	Grade obtained by the student	Credit value (b)	Grade Points (a x b)
AHS 101	Course - 1	4	B	8	32
AHS 103	Course - 2	4	B	8	32
AHS 105	Course - 3	3	A+	10	30
AHS 107	Course - 4	4	C	7	28
AHS 109	Course - 5	5	A	9	45
TOTAL		20	-	-	167

1st Semester GPA = Total grade points / total credits
167/20 = **8.35**

Suppose in **2nd semester GPA = 7** with respective course credit 25

Then, **1st Year CGPA** = $\frac{(8.35 \times 20) + (7 \times 25)}{20 + 25} = 7.6$

8. Carry over rule / Progression Criteria to higher semesters

The eligibility for promotion to the next academic year is subject to securing the minimum academic performance as specified below:

8.1. First to second year (progression to third semester): A minimum of 65% of the credits at the end of the first year (includes first and second semester credits)

8.2. Second to third year (progression to fifth semester): A cumulative minimum of 75% of the credits at the end of the second year (includes first, second, third and fourth semester credits)

8.3. Third year to fourth year (progression to seventh semester), applicable for 4½ year programs – BPT, BOT, BPO: A cumulative minimum of 85% of the credits at the end of the third year (includes first, second, third, fourth, fifth and sixth semester credits).

8.4. Student will be eligible for internship only after successful completion of the entire course work, i.e. earn 100% credits of the program

9. Program Exit / Probation Criteria

9.1 First year students who have failed to secure a minimum credit (as specified in progression criteria / carry over rule section), will be on **probation for next one year**. During that period, he / she will not be permitted to attend the second year / III semester classes and have to appear only for examination of the respective examination cycle only (during December / May) in order to acquire the credits for promotion to higher semester. In the event of failure to acquire the required credits even by the end of second year (65%), he / she has to **exit the program**. This exit policy from the program is applicable only for first year students failing to acquire the required credits even after the probation period.

9.2 From second year onwards, in the event of failing to acquire required credits (75% or 85% of the respective year), the students will be on academic probation. During that period, he / she will not be permitted to attend the classes of higher semester and have to appear only for examination (during December / May) of the failed courses in order to acquire the required credits for progression. From second year onwards, even though a student

has failed to acquire the minimum credits, he/she will not be required to exit from program.

9.3 However, the student must complete all the course work requirements and credits by a **maximum of double the program duration**.

9.3.1 For the program duration of 3+1 years' program, all the academic course work needs to be completed within the duration of 8 years.

9.3.2 For the program duration of 4 years 6 months' program, all the academic course work needs to be completed within the duration of 9 years.

10. Semester Break

10.1 Students will have a semester break following their odd and even end-semester examinations as per the academic calendar.

11. Internship

11.1 Internship will be for a duration of 6 months or 1 year as per the respective program regulation

11.2 Any components/ activities that need to be evaluated as part of internship without reflecting it in the CGPA.

11.3 The intern should abide by the rules and regulations of the organization during the period of internship.

11.4 An internship certificate with details of activities (including externship), clinical /relevant areas of postings with hours and research project will be issued to a candidate on completion of the Internship. The certificate must be authenticated by the HOD/Coordinator and HOI.

11.5 **Degree is awarded** only on successful completion of internship.

Head of the Department

Dean

Deputy Registrar - Academics

Registrar