Mangalore University
Medical Physics Division

M. Sc. in Medical Physics Programme

Revised Syllabus

[Prepared as per new Regulations governing the **C**hoice **B**ased **C**redit (CBCS) **S**ystem for Two Years (Four Semester) post-graduation programme]

University Science Instrumentation Centre
Mangalore University
Mangalagangotri-574 199
2019-20

MANGALORE UNIVERSITY
MEDICAL PHYSICS DIVISION

REGULATIONS AND SCHEME OF EXAMINATIONS FOR TWO – YEAR (FOUR SEMESTERS) MASTER'S DEGREE PROGRAMME IN MEDICAL PHYSICS FOR CHOICE BASED CREDIT SYSTEM (CBCS)

Title and Commencement of the programme:

The programme shall be called **Master of Science in Medical Physics(M. Sc. in Medical Physics)**.

Learning objectives of the programme:

- To provide Medical Physics support with the goal of improving the effectiveness and safety in the use of physics and technologies in medicine, especially in low-to-middle income countries.
- To advise, guide, support and/or participate in training through(i) the development of training programs,(ii) participation in training programs,(iii) exchanges of staff and/or students, and/or(iv) facilitation of e-learning.
- To advise, guide, support and/or participate in activities associated with medical physics-related technologies, especially those related to radiation medicine, including:(i) the design of such technologies and related facilities,(ii) the acquisition/purchase of such technologies,(iii) the commissioning of such technologies,(iv) the development and/or review of quality assurance/quality control programs, and(v) the development and/or review of safety-related activities, especially those related to ionizing radiation.
- To build a database of qualified medical physicists with a keen interest in supporting the Vision, Mission and Objectives of Medical Physics for World Benefit. These individuals would generally be members of Medical Physics for World Benefit.

Programme Outcomes:

- Acquaint with and understand about the basic theories and concepts of physics applied in medical physics discipline.
- Capable of designing, developing and conducting teaching and training programmes related to medical physics discipline.
- Work as medical physicist and practice consultancy.
- Ensure radiation protection and safety to both general public and patients.
- Augmenting national and international radiation emergencies.

Programme Specific Outcomes:

- Understand the role of nuclear and radiation physics in health applications.
- Learn about radiation sources, detectors and radiation generators.

- Acquaint with various instruments used in diagnosis and therapy using nuclear radiations and radioisotopes.
- Install, operate, maintain the equipment used in diagnosis and therapy and provide quality assurance.
- Learn about nuclear medicine, its practice and protocols of different applications.
- Equip with knowledge to provide and practice radiation protection and safety.
- Practice as Medical Physicists and Radiological Safety Officers in hospitals, medical colleges and radiation installations.
- Teach and train the students on various aspects of medical physics and conduct research.

Eligibility for Admission:

Candidates who have passed the three year B.Sc. degree examination of Mangalore University or any other University considered as equivalent thereto with Physics as major / optional / special subject are eligible for the programme provided they have studied Mathematics as major / optional / special / minor / subsidiary subject for at least two years and secured a minimum of 65%(60% for SC/ST/Category-1 candidates) marks in Physics.

Duration of the Course:

i. **Duration**: The duration of Master Degree Programmes shall extend over 4 semesters each of a minimum of 16 weeks (90 actual working days) of instruction and 2 to 3 weeks for preparation and examination.

ii. **Maximum period for the completion of the programme**: The candidate shall complete the programme within five years from the date of admission. The term completing the programme means passing all the prescribed examinations after the prescribed period for completing the programme.

iii. **Internship**:

   a. Internship is an option and not a part of the course work.

   b. Mangalore University will assist the students those who complete their M. Sc. in Medical Physics course in doing their internship in well-equipped radiation therapy departments or oncology centres/hospitals.

   c. The candidate would be eligible to work as Medical Physicist and becomes eligible to appear for Radiological Safety Officer (RSO) qualifying examination conducted by Atomic Energy Regulatory Board (AERB) in coordination with Radiological Physics & Advisory Division (RP&AD), Bhabha Atomic Research Centre (BARC) only on completion of one year internship.

   d. The institute/hospital/Centre where student(s) undergo 12 months internship and the supervising personnel will be certifying the completion of internship.

Course Pattern Highlights:

i. The M.Sc. in Medical Physicsprogramme shall comprise “Core” and “Elective” courses. The “Core” courses shall further consists of “Hard” and “Soft” core courses. Hard core courses shall have 4 credits and soft core courses shall also have 4 credits. Further, there shall be two Open Electives carrying 3 credits each. Total credit for the programme shall be 91 including open electives.

ii. Core courses are related to the discipline of the M.Sc. in Medical Physics programme. Hard core papers are compulsorily studied by a student as a core requirement to complete the programme of M.Sc. in Medical Physics. Soft core papers are elective but are related to the discipline of the programme. Two open elective papers of 3 credits each shall be offered in the II and III semester by the department and they will be chosen from the students unrelated to the programme within the faculty or across the faculty.

iii. Total credit for the M.Sc. in Medical Physics programme is 91. Out of the total 91 credits of the programme, the hard core (H) shall make up 62 % of the total credits; soft core (S) is 38 % while the open electives (OE) will have a fixed 6 credits (2 courses with 3 credits each).

Distribution of Credits

Semester	Hard Core (4 Credits)/ Project (5 Credits)				Soft Core (4 Credits)			Open Elective (3 Credits)		Total Credits
	No. of courses			Total Credits	No. of courses		Total Credits	No. of courses	Total Credits	
	T	P	Proj.		T	P				
I	3	1	---	16	2	---	8	---		24
II	2	1	---	12	1	1	8	1	3	23
III	2	1	---	12	2		8	1	3	23
IV	2	---	1	13	2		8			21
Total	**9**	**3**	**1**	**53**	**7**	**1**	**32**	**2**	**6**	**91**

T – Theory; P – Practical ;Proj. - Project

Distribution of Teaching/Practical Time and Credits

Semester	Theory/ Practical	Hard Core (4 Credits)			Soft Core (4 Credits)			Open Elective (3 Credits)			Total Credits
		No. Cs	Hrs	Total Crs	No. Cs	Hrs	Total Crs	No. Cs	Hrs	Total Crs	
I	Theory	3	3X4=12	16	2	2X4=8	08				24
	Practical	1	2X4=08								
II	Theory	2	2X4=08	12	1	1X2=4	08	1	1X3=3	3	23
	Practical	1	2X4=08		1	2X4=8					
III	Theory	2	2X4=08	12	2	2X4=8	08	1	1X3=3	3	23
	Practical	1	2X4=08								
IV	Theory	2	2X4=08	13	2	2X4=8	08				21
	Practical				2	2X4=8					
	Project	1	1X5=05								
Total Cr				**53**			**32**			**6**	**91**

Cs – Course; Cr/s – Credit/s; Hrs - Hours

Details of Courses & Credits for Four Semesters

Hard Core (H)					Soft Core (S)				Total Credits	Total Cr for Practical			Open Elective (OE)	Total Credits
T	P	Proj	Total Cr	%	T	P	Total	%		H	S	Total		
9	3	1	53	**62**	7	1	32	**38**	85	12	4	**16**	**6**	**91**

T – Theory; P – Practical; Proj. – Project; H – Hard Core; S – Soft Core;
OE – Open Elective; Cr - Credit

NOTE:

FIRST SEMESTER: The first semester consists of five theory courses, out of whichthree are hard core and two are soft core (4 hours per week for each paper and shall carry 4 credits for each paper)and twopractical (hard core, each practical is of 4 hours duration per week and carries 2 credits). The students have to come twice a week for each of the practical paper.

SECOND SEMESTER: The second semester consists of three theory courses, out of which two are hard core and one is soft core (4 hours per week and carry 4 credits for each course); and four practical (one hard core and one soft core) of 4 hours duration each (totally 16 hours per week and each practical carries 2 credits). The students have to come four times a week for each of the practical paper. In addition there shall be an open elective course to be opted by the student from other departments (3 hours per week and shall carry 3 credits).

THIRD SEMESTER: The third semester consists of four theory courses, out of which two are hard core and two are soft core courses (each course is of 4 hours per week for a paper and shall carry 4 credits) and two practical (one hard core, 8 hours per week and each practical course carries 2 credits). The students have to come twice a week for each of the practical papers. In addition there shall be an open elective course to be opted by the students from other departments (3 hours per week and shall carry 3 credits).

FOURTH SEMESTER: The fourth semester consists of four theory courses, out of which two are hard core and two are soft core (each course is of 4 hours per week and carry 4 credits) and two practical (one soft core, each practical is of 4 hours per week and carries 2 credits). The students have to come twice a week for each of the practical papers. There shall be a compulsory project work which has to be under taken by all the students of the fourth semester. The project work is a hard core having duration of 10 hours per week and carries 5 credits.

Scheme of Examination, Credits and Marks

SEMESTER	**Theory/practical**	**Exam. hours**	**Marks (Theory + Internal Assessment)**	**Credits**	**Total**
I Semester	5 Theory courses (3 hard core + 2 soft core)	3 hrs each	70 + 30 each	5 x 4 = 20	500
	2 Practicals (hard core)	4 hrs each	70 + 30 each	2 x 2 = 4	200
II Semester	3 Theory courses (2 hard core + soft core)	3 hrs each	70 + 30 each	3 x 4 = 12	300
	1 Theory course (open elective)	3 hrs	70 + 30 each	1 x 3 = 3	100
	4 practical (1 hard core + 1 soft core)	4 hrs each	70 + 30 each	4 x 2 = 8	400
III Semester	5 Theory courses (2 hard core + 2 soft core)	3 hrs each	70 + 30 each	4 x 4 = 16	400
	1 Theory course (open elective)	3 hrs	70 + 30 each	1 x 3 = 3	100
	2 practical (hard core)	4 hrs each	70 + 30 each	2 x 2 = 4	200
IV Semester	4 Theory courses (2 hard core + 2 soft core)	3 hrs each	70 + 30 each	4 x 4 = 16	400
	Project (hard core)		70 + 30 (Viva-voce)	1 x 5 = 5	100
			Grand Total	91	2700

Internal assessment:

i. **Theory:** Marks for internal assessment shall be based on 2 compulsory tests. Tests will be conducted for 30 marks and time duration will be 90 min. Average marks from both the tests will be considered as final internal assessment marks. Test papers shall be set and evaluated by concerned teachers.

ii. **Practical:** Practical internal assessment marks is based on viva-voce and practical records in the semesters and carries 30 marks for each practical course.

Project Report:

There shall be a project in the fourth semester for 100 marks and carries 5 credits. The project will be submitted in the form of a project report/dissertation and shall be evaluated for 70 marks by two examiners, one external and one internal from out of the panel of examiners prepared by the BoS, and approved by the University. Remaining 30 marks shall be for internal assessment and will be based on seminars and continuous assessment of the project work.

Theory Examination:

i. **Hard Core and Soft Core:**

Each theory course shall carry a maximum of 100 marks out of which 30 marks shall be for internal assessment. The remaining 70 marks shall be for University examination. University examination shall be conducted as per the rules and regulations prescribed by the University. Question paper for the University examination is of three hours duration shall be set as per the model given below:

a. **Part-I:** Six questions (at least one question from each unit) carrying 4 marks each of which five questions have to be answered (5x4= 20 marks).

b. **Part-II:** One question from each unit (internal choice) of the syllabus (there are 5 units) carrying 10 marks (5x10= 50 marks). A question may have not more than 3 subdivisions [eg. Question 1 (a) (b) (c)]

ii. **Open Elective:**

Each open elective course shall carry a maximum of 100 marks out of which 30 marks shall be for internal assessment. The remaining 70 marks shall be for University examination. University examination shall be conducted as per the rules and regulations prescribed by the University. Question paper for the University examination is of three hours duration shall be set as per the model given below:

a. **Part-I:** Seven questions (at least two questions from each unit) carrying 4 marks each of which five questions have to be answered (5x4= 20 marks).

b. **Part-II:** Eight questions(at least two questions from each unit) carrying 10 marks each of five questions have to be answered (5x10= 50 marks). A question may have not more than 3 subdivisions [eg. Question 1 (a) (b) (c)]

Practical Examination:

Each practical course shall carry a maximum of 100 marks out of which 30 marks shall be for internal assessment and remaining 70 marks shall be for final practical examination. The marks shall be awarded in the examination based on the procedure, conduct of the practical, results and viva voce related to the practical.

MANGALORE UNIVERSITY

M. SC. DEGREE PROGRAMME IN MEDICAL PHYSICS: CBCS

(Effective from the Academic year 2020- 2021)

COURSE PATTERN AND SCHEME OF EXAMINATION

Course Code	**Description of the Papers**	**Teaching Hrs/ week**	**Credit**	**Max Marks: (Exam + IA)**
I Semester				
MPH 401	Fundamentals of Physics	4	4	70 + 30
MPH 402	Nuclear and Radiation Physics	4	4	70 + 30
MPH 403	Radiological Mathematics	4	4	70 + 30
MPS 404	Human Anatomy and Physiology	4	4	70 + 30
MPS 405	Basic Electronics and Biomedical Instrumentation	4	4	70 + 30
MPS 406	Biophysics	4	4	70 + 30
MPP 407	Medical Physics Practical – I	4	2	70 + 30
MPP 408	Medical Physics Practical – II	4	2	70 + 30
II Semester				
MPH 451	Radiation Detection and Measurement	4	4	70 + 30
MPH 452	Radiation Dosimetry and Standardization	4	4	70 + 30
MPS 453	Fundamentals of Cancer Biology	4	4	70 + 30
MPS 454	Biostatistics	4	4	70 + 30
MPE 455	Industrial Application of Radiation and Radioisotopes	3	3	70 + 30
MPP 456	Medical Physics Practical – III	4	2	70 + 30
MPP 457	Medical Physics Practical – IV	4	2	70 + 30
MPP 458	Medical Physics Practical – V	4	2	70 + 30
MPP 459	Medical Physics Practical – VI	4	2	70 + 30

III Semester				
MPH 501	Clinical Radiation Biology	4	4	70 + 30
MPH 502	Physics of Medical Imaging	4	4	70 + 30
MPS 503	Physics of Nuclear Medicine	4	4	70 + 30
MPS 504	Clinical Aspects of Radiation Therapy	4	4	70 + 30
MPS 505	D3 - IPR, Biosafety & Bioethics	4	4	70 + 30
MPE 506	Applications of Radiation and Radioisotopes in Health and Agriculture	3	3	70 + 30
MPP 507	Medical Physics Practical – VII	4	2	70 + 30
MPP 508	Medical Physics Practical –VIII	4	2	70 + 30
IV Semester				
MPH 551	Physics of Radiotherapy (Radiotherapy – I)	4	4	70 + 30
MPH 552	Radiation Protection Standards and Safety	4	4	70 + 30
MPS 553	Modern Trends in Radiotherapy (Radiotherapy – II)	4	4	70 + 30
MPS 554	Nuclear Reactors, Particle Accelerators, Industrial Applications of Radiation and Environmental Radioactivity	4	4	70 + 30
MPS 555	Research Methodology & Communication	4	4	70 + 30
MPP 556	Project	10	5	70 + 30

Summary of the course patterns:

Summary of the course patterns, hours of instructions per course/paper per week, marks and credits assigned to different courses/papers in different subjects of study in the M. Sc. in Medical Physics Degree programmes is as follows:

I Semester

Sl. No.	Course Code	Course Title	No. of Hrs	Credits				Total Credits
				L	P	T	S	
Hard Core – Compulsory component								
1	MPH 401	Fundamentals of Physics	4	4				4
2	MPH 402	Nuclear and Radiation Physics	4	4				4
3	MPH 403	Radiological Mathematics	4	4				4
Soft Core – Elective component (Select any 2 courses)								
4	MPS 404	Human Anatomy and Physiology	4	4				8
5	MPS 405	Basic Electronics and Biomedical Instrumentation	4	4				
6	MPS 406	Biophysics	4	4				
Practical (compulsory)								
7	MPP 407	Medical Physics Practical – I	4		2			2
8	MPP 408	Medical Physics Practical – II	4		2			2
Total Credits for I Semester								**24**

HC – Hard Core; SC – Soft Core; L – Lecture; P – Practical; T – Tutorial; S - Seminar

II Semester

Sl. No.	Course Code	Course Title	No. of Hrs	Credits				Total Credits
				L	P	T	S	
Hard Core – Compulsory component								
1	MPH 451	Radiation Detection and Measurement	4	4				4
2	MPH 452	Radiation Dosimetry and Standardization	4	4				4
Soft Core – Elective component (Select any 1 course)								
3	MPS 453	Fundamentals of Cancer Biology	4	4				4
4	MPS 454	Biostatistics	4	4				
Open Elective for other discipline students								
5	MPE 455	Industrial Application of Radiation and Radioisotopes	3	3				3
Practical (compulsory)								
6	MPP 456	Medical Physics Practical – III	4		2			2
7	MPP 457	Medical Physics Practical – IV	4		2			2
8	MPP 458	Medical Physics Practical – V	4		2			2
9	MPP 459	Medical Physics Practical – VI	4		2			2
Total Credits for II Semester								**23**

III Semester

Sl. No.	Course Code	Course Title	No. of Hrs	Credits L	P	T	S	Total Credits
Hard Core – Compulsory component								
1	MPH 501	Clinical Radiation Biology	4	4				4
2	MPH 502	Physics of Medical Imaging	4	4				4
Soft Core – Elective component (Select any 2 courses)								
3	MPS 503	Physics of Nuclear Medicine	4	4				8
4	MPS 504	Clinical Aspects of Radiation Therapy	4	4				
5	MPS 505	D3 - IPR, Biosafety & Bioethics	4	4				
Open Elective for students of other discipline								
6	MPE 506	Applications of Radiation and Radioisotopes in Health and Agriculture	3	3				3
Practical (compulsory)								
7	MPP 507	Medical Physics Practical – VII	4		2			2
8	MPP 508	Medical Physics Practical –VIII	4		2			2
Total Credits for III Semester								**23**

IV Semester

Sl. No.	Course Code	Course Title	No. of Hrs	Credits L	P	T	S	Total Credits
Hard Core – Compulsory component								
1	MPH 551	Physics of Radiotherapy (Radiotherapy – I)	4	4				4
2	MPH 552	Radiation Protection Standards and Safety	4	4				4
Soft Core – Elective component (Select any 2 courses)								
3	MPS 553	Modern Trends in Radiotherapy (Radiotherapy – II)	4	4				8
4	MPS 554	Nuclear Reactors, Particle Accelerators, Industrial Applications of Radiation and Environmental Radioactivity	4	4				
5	MPS 555	Research Methodology & Communication	4	4				
Project – Compulsory component								
6	MPP 556	Project	10	5				5
Total Credits for IV Semester								**21**

Details of Courses & Credits for Four Semesters

Credits					**Total Credits**
Hard Core	**Soft Core**	**Total**	**Open Elective**	**Project**	
53 (62%)	**32 (38%)**	**85**	**6**	**5**(Included in HC)	**91**

MANGALORE UNIVERSITY
MEDICAL PHYSICS DIVISION

Syllabus for M. Sc. in Medical Physics Programme

Semester – I

MPH 401: Fundamentals of Physics

Teaching hours: Each Unit – 12 h

Objective:
To familiarise the students with the basics of fundamental physics required to understand the basic processes, interactions, and interconnectedness of nuclear radiations with both physical and life science disciplines.

Outcomes:

- Students will be familiar with the fundamental principles of physics required to understand the multidisciplinary nature of medical physics programme.
- They will learn basics of condensed matter physics, thermodynamic laws, basics of optical radiations and lasers useful to the programme.
- Students will learn basics of radio-frequency and microwave radiations and interaction with tissues.
- They will get familiar with basics of ultrasound radiations and their uses in medical applications.

Unit I: Condensed Matter Physics

Ionic Bonding; Bond Energy of NaCl, Lattice Energy of Ionic Crystals, Madelung Constant – Properties of Ionic Solids – Co-valent Bond; Saturation, Directional Nature, Hybridization, Properties – Metallic Bond; Properties – Intermolecular Bonds; Van der Waal's bonds, Dispersion Bonds, Dipole Bonds, Hydrogen Bonds.

States of matter - crystalline and amorphous materials; thin films and nano structures.Conductors, semiconductors and superconductors. Absorption processes - Photoconductivity – Photoelectric effect – Photovoltaic effect –Photoluminescene – Thermoluminescence – Flouresecnce – Radioluminesce- Phosphorescence.

Unit II: Thermal and Magnetic Properties of Solids

Specific Heat – Dulong and Petit Law- Einstein's Theory – Debye's Theory – Magnetism in Solids – Origin of Magnetic Properties of Materials - Bohr Magneton, Orbital, Electron Spin and Nuclear Spin – Types of magnetism; Diamagnetism-Langevin's Theory, Paramagnetism - Classical Theory (Langevin's Theory and Curie's Law), Weiss Theory, Paramagnetic Susceptibilty – Ferromagnetism, Hysterisis.

Unit III: Thermodynamics, Optics and Lasers

Thermodynamic system.- Laws of thermodynamics, Concept of entropy - principle of entropy increase - entropy and disorder.

Introduction to optical radiations: UV, visible and IR sources. Fiber optics in medicine.Microscopy in medicine – Birefringence, fluorescence microscope, confocal microscope.

Lasers: Theory and mechanism. Interaction of laser radiation with tissues – photothermal - photochemical – photoablation – electromechanical effect. Lasers in medicine – Laser surgery, applications of Ultrafast Pulsed Lasers -Lasers in dermatology, oncology and cell biology - Lasers in blood flow measurement - Hazards of lasers and their safety measures.

Unit IV: Radio Frequency and Microwave in Medicine

Production, properties and classification of electromagnetic radiation- Different sources of radiation - radio waves, microwaves, infrared, visible, ultra violet radiation, X-rays and Gamma-rays- production, physical properties and their interaction with tissues.

Interaction mechanism of RF and microwaves with biological systems - Thermal and non-thermal effects on whole body, lens and cardiovascular systems - tissue characterization and Hyperthermia and other applications

Unit V: Ultrasound in Medicine

Production, properties and propagation of ultrasonic waves - Bioacoustics – Acoustical characteristics of human body- Ultrasonic Dosimetry - High power ultrasound in theraphy – Ultrasound cardiography (UCG) – Doppler effect -Double doppler shift – doppler systems - ultrasonic tomography -applications of ultrasound in medicine.

Reference Books:

1. David J. Griffiths, *Introduction to Electrodynamics,* fourth edition [QC680.G74 2013]
2. Mark A. Heald and Jerry B. Marion, *Classical Electromagnetic Radiation* [QC661.H43 1995]
3. S.O. Pillai, Solid State Physics, New Age International Publishers, 6th Edition, 2015.
4. Solid State Physics, R.K. Puri, V.K. Babbar, S.Chand, 1st Edition, 1996.
5. Elementary Solid State Physics: Principles and Applications, M.A.Omar, Pearson Education Pvt. Ltd., Delhi, India, 4th Edition, 2004.
6. J. P. Woodcock, Ultrasonic, Medical Physics Handbook series 1, Adam Hilger, Bristol, 2002.
7. R. Pratesi and C. A. Sacchi, Lasers in Photo medicine and Photobiology, Springer Verlag, West Germany, 1980.
8. Harry Moseley, Hospital Physicists' Association, Non-ionizing radiation: microwaves, ultraviolet, and laser radiation, A. Hilger, in collaboration with the Hospital Physicists' Association, 1988.
9. Markolf H. Neimz, Laser-Tissue Interactions, Springer Verlag, Germany, 1996.

------*****------

MPH 402: Nuclear and Radiation Physics

Teaching hours: Each Unit – 12 h

Objective:

To acquaint the students about the basics of nuclear andradiation physics required to understand, appreciate and apply in diagnosis and therapy using nuclear radiations and radioisotopes.

Outcomes:

- Students will be familiar with the basics of nuclear physics including nuclear models and nuclear forces required to understand their interaction processes and behaviour with matter.
- They will understand basics of alpha and beta decay useful in health application of radioisotopes and radiations.
- Students will learn about nuclear reactions which are of primary importance in understanding the production of radioisotopes for therapy and diagnosis.
- They will get familiar with different kinds of radiations and radioisotopes and their interaction with matter.
- They will also learn basicsof electronics involved in radiation detection and counting systems.

Unit I: Basics of Nuclear Physics

General properties of the nucleus and nuclear decay: Constituents of nucleus and their properties. Mass of the nucleus - binding energy. Charge and charge distribution. Size - estimation and determination of the nuclear radius. Nuclear radius from mirror nuclei - spin statistics and parity. Magnetic moment of the nucleus.Quadrupole moment.
Nuclear decay - Alpha decay - quantum mechanical tunnelling - wave mechanical theory.

Beta decay - continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay - Kurie plots and ft-values - selection rules.Detection of neutrino - non-conservation of parity in beta decay. Gamma decay - selection rules - multipolarity - Internal conversion (qualitative only).

Unit II: Nuclear Forces and Nuclear Models

Nuclear forces and nuclear models: Nature of nuclear force - short range, saturation, spin dependence and charge independence. Ground state of the deuteron using square well potential - relation between range and depth of the potential.Yukawa's theory of nuclear forces and explanation of anomalous magnetic moment of the nucleus.
Review of nuclear models - liquid drop model - semi empirical mass formula - stability of the nuclei against beta decay - mass parabola. Shell model (qualitative treatment).

Unit IV: Nuclear Reactions

Nuclear reactions - Cross section for a nuclear reaction. 'Q' equation of a reaction in laboratory system - threshold energy for a reaction. Centre of mass system for nucleus-nucleus collision. Non-relativistic kinematics.Relation between angles and cross sections in lab and CM systems.
Reactor physics: fission chain reaction. Slowing down of neutrons - moderators.Conditions for controlled chain reactions in bare homogeneous thermal reactor.Critical size.Effect of reflectors.Brief introduction of nuclear fuel cycle.Breeder Reactors.

Unit IV: Interaction of Radiation with Matter
Interaction of radiation with matter: Interaction - stopping power - energy loss characteristics, particle range - energy loss in thin absorbers. Scaling laws.Interaction of fast electrons - specific energy loss.Electron range and transmission curves.

Interaction of gamma rays - interaction mechanisms - photoelectric absorption, Compton scattering and pair-production. Gamma ray attenuation - attenuation coefficients, absorber mass thickness, cross sections.

Interaction of neutrons - general properties - slow down interaction, fast neutron interaction, neutron cross sections. Radiation exposure and dose – dose equivalent.

Unit IV: Nuclear electronics
Preamplifier circuits, linear and pulse amplifier, pulse shaping, pulse stretching. Wilkinson type analog to digital converter. Pulse discriminators - coincidence and anticoincidence circuits - memories, single and multichannel analysers – on-line data processing - time to amplitude converter - charge sensitive amplifier. Basic principles of measurement techniques such as collimation, shielding, geometry and calibration.

Text Books:

1. Segre E, 'Nuclei and Particles', II Edn. (Benjamin, 1977)
2. Knoll G F, Radiation Detection and Measurement', II Edn. (John Wiley, 1989)
3. Eisenbud M, 'Environmental Radioactivity' (Academic Press, 1987)
4. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I & II (S Chand & Company, 1994).

Reference Books:

1. Patel S B, 'Nuclear Physics - An Introduction' (Wiley Eastern, 1991)
2. Krane K S, 'Introductory Nuclear Physics' (John Wiley, 1988)
3. Roy R K and Nigam P P, 'Nuclear Physics - Theory and Experiment' (Wiley Eastern Ltd., 1993)
4. Singru R M, 'Experimental Nuclear Physics' (Wiley Eastern, 1972)
5. Zweifel P F, 'Reactor Physics', International Student Edn. (McGraw Hill, 1973)
6. Kapoor S S and Ramamurthy V S, 'Radiation Detectors' (Wiley Eastern, 1986)
7. Henry Semat& John R AlBright, 'Introduction to Atomic and Nuclear Physics' V Edn. (Chapman & Hall, 1972)
8. Burcham W E, 'Nuclear Physics', II Edn. (Longman, 1963)
9. Mann W B, Ayres R L and Garfinkel, 'Radioactivity and its Measurements' (Pergamon Oxford, 1980)

10. Little field T A and Thorley N ‘Atomic and Nuclear Physics’, II Edn. (Nostrand Co., 1988).
11. K.S.Krane, "Introductory Nuclear Physics", (John Wiley & Sons)
12. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001.
13. F.M Khan : “Physics of Radiation Therapy” Fourth Edition.
14. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
15. H.E.Jones, J.R.Cunnigham, “The Physics of Radiology” Charles C.Thomas, NY, 1980.
16. W.J.Meredith and J.B.Massey “Fundamental Physics of Radiology” John Wright and sons, UK, 1989.
17. W.R.Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc.
18. London, 1981.
19. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.

------*****------

MPH 403: Radiological Mathematics

Teaching hours: Each Unit – 12 h

Objective:
To teach and familiarise the students with various concepts and principles, numerical and statistical methods; and tools required to learn and understand the various process of radiation and radioactivity data analysis including medical applications.

Outcomes:

- The student will learn the concept and principle of various statistical methods and technique for data analysis, error calculations in nuclear measurements, calculation in clinical methods and design of clinical experiments.
- They will learn various numerical methods such as Picard's method, Taylor's method, .Euler's method Newton-Raphson Method etc. They will get acquainted with the concept of Monte Carlo as well.
- They will develop mathematical skills in equation solving and interpolation of different kinds of data.
- They will also learn the computational tools and techniques including use of computational software applications such as METLAB, STATISTICA etc. and programming in C++.

Unit I: Probability, Statistics and Errors

Probability – addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data. Basic ideas of statistical distributions frequency distributions, average or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, median, dispersion, standard deviation, root mean square deviation, standard error and variance, coefficient variation, Accuracy, precision, bias, moments, skewness and kurtosis. Application to radiation detection – uncertainty calculations, Random error, Systematic error, probable error, error propagation, time distribution between background and sample, minimum detectable limit. Binomial distribution, Poisson Distribution,Gaussian distribution, exponential distribution – additive property of normal variants, confidence limits, Bivariate distribution, Correlation and Regression, Chi-square distribution, t-distribution, F-distribution.

Unit II: Counting and Medical Statistics

Statistics of Nuclear counting – Application of Poisson's statistics, Statistics of Radioactive Decay: resolving time and loss of counts, sample counting procedures – Goodness of-fit tests

– Lexie’s divergence co-efficient - Pearson’s Chi-square test and its extension – Random fluctuations, Evaluation of equipment performance –Signal-to-noise ratio - selection of operating voltage – Preset of rate meters and recorders – Efficiency and sensitivity of radiation detectors – Statistical aspects of gamma ray and beta ray counting – Special considerations in gas counting and counting with proportional counters – statistical accuracy in double isotope technique. Sampling and sampling distributions – confidence intervals.Clinical study designs and clinical trials.Hypothesis testing and errors.Regression analysis. Calculations Involved with Medical Decisions; Sensitivity, Specificity, Accuracy, Predictive Diagnostic Value

Unit III: Numerical Methods

Why numerical methods, accuracy and errors on calculations – round-off error, evaluation of formulae. Iteration for solving x = g(x), Initial Approximation and Convergence Criteria, Newton-Raphson Method. Taylor Series, approximating the derivation, numerical differentiation formulas.Introduction to numerical quadrature, Trapezoidal rule, Simpson’s rule. Simpson’s Three-Eighth rule, Boole rule, Weddle rule. Initial value problems.Picard’s method, Taylor’s method.Euler’s method, the modified Euler’s method.Runge-kutta method.

Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

Unit IV: Roots of equation and Interpolation

Bisection – False position method – Newton Raphson method – Gauss elimination mehod - Gauss Jacobi method – Gauss Seidal method – Inversion of a matrix using Gauss elimination method - LU decomposition - Gregory Newton’s forward and backward difference formula for equal intervals – Divided difference – Properties of divided difference – Newton’s divided difference formula – Lagranges interpolation formula for unequal intervals

Unit V: Computational Tools and Techniques

Computational packages: Overview of programming in C++, MATLAB/Mathematica and STATISTICA in data analysis and graphical methods.

Reference Books:

1. Hoffman, Numerical Methods for Engineers and scientists – 2nd Edition Revised and expanded.
2. A.C. Bajpai, I.M. Calus and J.A. Fairley Numerical methods for engineers and scientists – a student's course book, John Wiley & sons
3. Band W. Introduction to Mathematical Physics
4. Croxton – elementary statistics
5. Dahlberg G. Statistical Method of medical & biology students
6. Krasnorm.L. Ordinary differential equation
7. N.P. Bali & Dr. N.Ch. SrimannarayanaIyergar, A text book of Engineering Mathematics, Laxmi publications, 2001.
8. S. Chandra, A text book of Mathematical Physics, Narosa Publishing House.

------***------**

MPS 404: Human Anatomy and Physiology

Teaching hours: Each Unit – 12 h

Objective:
To acquaint the students about the structure and function of different kinds ofcells, tissues, organs;and important systems such as circulatory, digestive, respiratory, endocrine, reproduction and nervous systemsin human body from the point of view of radiodiagnosis and radiation therapy.

Outcomes:

- Students will acquaint with basic knowledge of cells, tissues, different kinds of bones and muscular systems; and understand surface anatomy.
- They will learn all important aspects of circulatory and digestive system.
- They will understand respiratory and endocrine systems.
- They will learn about reproduction and nervous system.
- They will also learn anatomy and physiology applied to radio diagnosis and radiotherapy.
- They will be able to identify different organs/structures using X-rays, CT and other images.

Unit 1: Surface anatomy

Cells, structure and functions, germ cells, pre-natal development – The tissues – the systems – skin, cartilage and bone – Bacteria –Inflammation – Injection – ulceration – neoplasma, bones – the skeleton – joints– The skeletal system – the skull – vertebral column, thorax Upper Extremity, Lower Extremity etc. – the muscular system -the thoracic cage – the media sternum, the diaphragm the abdominal cavity and abdominal regions –anatomy of the heart. Superior Extremities, Inferior Extremities, Ossification centers, Bone of Upper Limb, Radius and ulna, surface marker of Thorax, Abdomen, Head and Neck.

Unit 2: Circulatory system and Digestive system

Functions of mouth, tongue, teeth, esophagus, Salivary Glands, stomach, small intestine, Duodenum, large intestine, Jejunum, Ileum Pancreas, Liver, Biliary System.– digestion and assimilation of carbohydrates – Fats and proteins – Gastric juice – Pancreatic juice – Function of liver and spleen. Blood and circulatory system, Blood and its composition, RBC and WBC– blood grouping – coagulation of blood, Plasma, artery, vein, capillaries and heart structure and functions – Physiological properties of heart muscle, cardiac dynamics – EEG – blood pressure and its regulation.

Unit 3: Respiratory & Endocrine system

Physical laws of respiration – Nose, Pharynx, Bronchi - Trachea – Lungs and its functions – oxygen transport –Physiology of Respiration – Lung Volume and capacity, control, gas exchange. Pituitary glands and its functions – functions of adrenal, thyroid, and pancreas etc - secretion – chemistry – physiological actions, effects on removal effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action – Insulin.

Unit 4: Reproduction system & Nervous system

(a). Male: Reproductive System – Testis, Functions, ducts, Male infertility. (b) Female Reproductive System: Ovaries, Fallopian Tube, Vagina, Breast, reproductive Cycle, Menstruation, Maturation, Fertilization. Brain and spinal cord – its functions - central nervous system and Autonomic Nervous system functions – Physiology of special senses of hearing, taste vision.

Kidney and its functions – Formation and Excretion of Urine, Ureter, Urinary Bladder, Urethra, Micturation.Skin - Eye - Ear - Nose - Tongue.

Unit 5: Radiographic anatomy and diseases

Anatomy and physiology as applied to radio diagnosis and radiotherapy –X-ray anatomy – CT/MRI anatomy-surface anatomy applied to Radio-diagnosis (RD) and Radio therapy (RT) –introduction to the nature of diseases and trauma-inflammation and infection. Anatomy and Physiology as applied to radio diagnosis and radiotherapy –Radiographic anatomy (including cross sectional anatomy) – identify the different organs/structures on plain X-rays, CT scans and other available imaging modalities. Normal anatomy and deviation for abnormalities.

Reference Books:

1. C.H. Best and N.B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1986.
2. C.K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 1988.
3. J.R. Brobek, Physiological Basis of Medical Practice, Williams and Wilkins, London, 1995
4. Tortora, Gerard, “Principles of anatomy and physiology”, John Wiley & Sons Inc., New York, 2000.
5. Ross and Wilson, “Anatomy and Physiology”, Churchill Livingstone; 2005.

------***------**

MPS 405: Basic Electronics and Biomedical Instrumentation

Teaching hours: 12 h each unit

Objective:

To familiarise the students about the fundamentals of electronics, electronic circuits, electrical/electronic signals and biomedical instruments used in diagnosis and therapy for measuring, recording, storing, and analyzing the signals and data analysis.

Outcomes:

- Students will learn the basic electronics and electronic circuits used in various devices.
- They will be familiar with both analog and digital electronics and electronic circuits used in biomedical devices.
- They will acquire knowledge onbiomedical instrumentation and their applications.
- They will be learning biomedical signal monitoring, recording, storing and analyzing.
- They will also learn about equipments used in diagnosis and therapy.

Unit I: Fundamentals of Electronics

Construction and Operation of Diode, Zener Diode, Bipolar Junction Transistor (BJT), Field Effect Transistor (FET), MOSFET, Biasing Circuit. Timer based Multivibrators. Power Supply: Rectifiers, Filters, Zener Voltage Regulator, Voltage Regulator ICs.

Unit II: Analog Electronics

Bipolar Junction Transistors - Amplifier Configurations: CB and CE Configuration Characteristics, CC, Cascode. JFET Amplifier. OPAMP: Op-Amp-Circuit Symbol, ideal Op-Amp-Characteristics-CMRR, Applications: Adder, Subtractor, Analog Integrator, Analog Differentiator, Voltage-to-Current Converter, Current-to-Voltage Converter and Logarithmic Amplifier.

Unit III: Digital Electronics

Logic Gates: Boolean Algebra, Boolean Laws – De-Morgans Theorem, Implementation of Logic Circuits from Truth Table – Sum-of-Products method and Products-of-Sum method. Combinational Circuits: Multiplexer and de-Multiplexer Circuits, BCD to Decimal Decoders, Seven Segment Decoders, Decimal to BCD Encoder. Arithmetic Building Blocks: Half-Adder and Full-Adder., Digital Comparator. Flip Flops: RS, Clocked RS, D-Flip Flop, Edge-triggered D Flip Flop – J K Flip Flop. Sequential Logic Circuits: Registers - Shift Registers, Applications. Counters: Ripple Counters - Up, Down and Up-Down Ripple Counters, Asynchronous and Synchronous Counters. Analog-to-Digital and Digital-to-Analog Converters.Microprocessor – Principles, Types, Working and Applications.

Unit V: Bioelectric Signal Monitoring and Recording

Origin and Characteristics of Bioelectric Signals and Recording. Electrodes - Types, Design, Properties and Utility, Skin Contact Impedance of Electrodes, Noise Suppression Techniques. Transducers and Measurement of Physiological Events, Transducers – Properties, Principles and Working.The origin of Biopotentials, Resting and Action Potentials. Amplifiers and Signal Processing - ECG, EEG, EMG.

Unit V: Biomedical Instrumentation

Diagnostic Equipments: pH meters, Audiometer, Endoscopes, Blood Flow Meters, Pulmonary Function Analyzers, Blood Gas Analyzer, Oximeters: Principle and Working.

Therapeutics Equipments: Cardiac Pace Makers, Defibrillators, Hemodialysis Machines, Short-wave and Micro-wave Diathermy, Ultrasonic Therapy, Pain relief through Electrical Stimulation, Surgical Diathermy. Laser: Principle of Operation, Types, Laser Tissue Interaction, Biomedical Applications of Laser in Surgery and Therapy. Lithotripters, Anaesthesia Machine, Ventilators, Radiotherapy Equipment, Automated Drug Delivery Systems.

Reference Books:

1. Electronic Devices and Circuit Theory. Robert L. Boylestad, Louis Nashelsky. Prentice Hall Publisher, 11th Edition, 2012.
2. Electronic Principles. Albert Malvino and David J Bates. Tata McGraw Hill, 7th Edition, 2007.
3. Digital Logic and Computer Design. M. Morris Mano. Prentice Hall Publisher, 11th Edition, 2002
4. A text book of Electronics by – SantanueChattopadhyay, New Central Book Agency, Kolkata, 2006.
5. Digital Principles and Applications, A.P. Malvino and D.P. Leach, Tata McGraw-Hill Publishing Co, New Delhi, 1996.
6. Electronic Principles and Applications, A.B. Bhattacharya, New Central Book Agency, Kolkata, 2007.
7. Introduction to Microprocessors, A.P. Mathur, Tata McGraw-Hill Publishing Co, New Delhi, 2005.
8. Digital Fundamentals, Floyd T L, 8th Edition, Person Education Asia Publications,

2002.
9. Basar E. (1976), Biophysical and physiological system Analysis, Addition-Wesley.
10. Cameron J. R. and skofronick J.G. (1978), Medical Physics, John willey and sons.
11. Handbook of Biomedical Instrumentation, R.S. Khandpur, Second Edition, Tata McGraw-Hill Publishing Company Limited, 2003.
12. Introduction to Biomedical Equipment Technology, Joseph J. Carr and John M. Brown, Fourth Edition, Pearson Education, 2001.
13. Medical Instrumentation: Application and Design, Fourth Edition, John G Webster (Ed), John Wiley, 2010.

------*****------

MPS 406: Biophysics

Teaching hours: Each Unit – 12 h

Objective:

To familiarise the students with applications of principles and methods of physics in biological sciences and Biophysics required understanding the basic processes, interactions, and interconnectedness of physics with life science disciplines.

Outcomes:

- Students will be familiar with concepts such as absorption, adsorption, chromatographic methods, electrical and mechanical basis used in measurements.
- They will learn about important analytical equipment used in measuring electrical, mechanical, and various other parameters and their principles of operation.
- They will acquire knowledge on membrane and molecular biophysics.
- Develop acquaintance and understand the basic principles of interaction of radiation and their effects on biological materials.
- Students will be familiar with biosensors working on the principles of physics.

Unit I: Physicochemical Fractionation, Electro-analytical Techniques and Spectroscopic Techniques.

Chromatography-Basic Concepts of Adsorption & Partition Chromatography, Principle, Experimental set-up, Methodology & Applications of Adsorption & Partition Chromatography methods i.e. Paper Chromatography and Thin Layer Chromatography.Electrophoresis- Principle, Electrophoretic mobility (EPM) estimation, factors affecting EPM, Instrument design & set-up, Methodology & Applications – Paper Electrophoresis and Gel Electrophoresis. Spectroscopy - Principle, instrumentation and application of spectroscopic instruments: UV Visible, IR spectroscopy, Raman spectroscopy. ONLY Principles and applications of CD, ORD, Fluorescence, Mass, NMR, ESR and Atomic absorption spectroscopy.

Unit II: Hydrodynamic Techniques and Optical & Diffraction Techniques.

Centrifugation & Ultracentrifugation - Basic principles, Forces involved, techniques – principles and applications.Viscometry- General features of fluid flow (streamlined and turbulent) nature of viscous drag for streamlined motion. Definition of viscosity coefficient, expression for viscosity coefficient of gases (with derivation).Principle, Instrument Design, Methods & Applications of Polarimetry, Light scattering, Refractometry, Atomic Force

Microscopy.Dichroic ratio of proteins and nucleic acids.Structure determination using X-ray diffraction.

Unit III: Membrane Biophysics and Molecular Biophysics.

Cell membrane models, Composition of biological membranes. Membrane skeleton, elastic properties of membrane.Molecular motion in membrane and membrane fluidity. Nature & magnitude of cell surface charge, Electric properties of membranes: electricdouble layer, Poisson-Boltzmann theory of electric double layer. Chloroplast membrane & energy transduction, Energy transduction through mitochondrial membrane.

Water as universal solvent in biological system, principles of protein structure and confirmation. Forces involved in bimolecular interactions, Ramchandran plot, dihedral/torsional angles. Structure of nucleic acids: composition of nucleic acids, Chargoff'sRule in DNA, RNA base compositions, supercoiling of DNA (linking, twisting and writhing – brief ideas). Interaction of ligands with biomolecules.

Unit IV: Radiation Biophysics and Radiolabeling Techniques.

Radiation Biophysics: Introduction to radiations, Atomic structure, types of radioactive decay, half-life and units of radioactivity. Effects of ionizing and non-ionizing radiations on living systems.Detection and measurement of radioactivity methods, autoradiography.

Radiolabeling Techniques: Properties of different types of radioisotopes, applications of radioisotopes in biology and medicine, isotope dilution techniques, detection and measurement of radioisotopes, incorporation of radioisotopes in biological tissues and cells, radio dating, molecular imaging of radioactive material, safety measures in handling radioisotopes.

Unit V: Electrophysiological and Biophysical Methods

Basic of membrane potentials, principles of bioelectricity, single neuron recording, patch-clamp recording. Principle, Instrument Design, Methods & Applications of ECG, EEG, EMG, pharmacological testing,PET, SPECT, MRI, fMRI, CAT. Biosensors – principles, design, working, types and applications.

Reference Books

1. Ackerman E.A. Ellis, L.E.E. & Williams L.E. (1979), Biophysical Science, Prentice-Hall Inc.
2. Bulterl.A.V. And Noble D.Eds. (1976), Progress in Biophysics and Molecular Biology (all volumes) pergamon, Oxford.
3. Casey E.J. (1967), Biophysics, concepts and mechanisms. Affiliated East west press.
4. Chang R. (1971), Basic principles of spectroscopy, McGraw-Hill.
5. Crabbe P. (1972), ORD and CD in chemistry and biochemistry, Academic Press.
6. Haschemyer R.N. and Haschemyer A.E.B.V. (1973), Proteins, John willey and sons.
7. Hughes W. (1979), Aspects of Biophysics, John willey and sons.
8. James T.L. (1975), Nuclear Magnetic Resonance in Biochemistry, Academic press.
9. Quagliokiello E., Palmieri F. and singer, T.P. (1977), Horizons in Biochemistry and Biophysics (all volumes) Addison Wesley Publishing Company.
10. Setlow R.B. and pollard E.L. (1962), Molecular Biophysics, Pergamon Press.
11. Spragg S.E. (1980), Physical Behavior of macromolecules with biological functions, John willey and sons.
12. Stanford J.R. (1975), Foundation of Biophysics Academic press.
13. Henry B. Bull (1971), An Introduction to physical biochemistry, F.A.Devis Co.
14. H. H. Perkampus (1992), UV-VIS Spectroscopy and Its applications, Springer-Verlag.
15. Garry D. Christian, James E.O’reilvy (1986), Instrumentation analysis, Alien and Bacon, Inc.
16. S.M.Khopkar (1984), Basic Concepts of Analytical chemistry, Willey eastern lit.

------*****------

Semester – I: Practical
Electronics

MPP 407: Medical Physics Practical-I (4 hr in a week)

Objective:
To import the practical knowledge of designing and constructing the electronic circuits useful in understanding characteristics of voltage, current, and power multipliers and regulators and to familiarise with amplifiers, oscillators and multi-vibrators.

Outcomes:

Students will be able to construct electronic circuits for testing various hypothesis and measurements such as:

- Voltage multiplier and characterise regulated power pack.
- Construct and characterise transistor based DC Voltage regulator.
- Construct and verify the operation of feedback amplifier.
- Construction of oscillator and free running multi-vibrator circuits.

List of experiments:

1. Construction of Voltage multiplier.
2. Regulated power supply using IC 7805.
3. DC voltage regulator using transistors.
4. Feedback amplifiers using Op-amp.
5. Phase shift oscillators using Op-amp.
6. Free running multivibrator using IC 555.
7. Matlab program to find area and circumference of the circle and plot the circle.
8. Matlab Program to find the roots of quadratic equation.
9. Matlab program to matrix addition, subtraction and multiplication.
10. Matlab program to plot the graph for the equation F(x) = 3x+4.

*** Additional experiments may be included.**

-*-*-*-*-*-

Semester – I: Practical
Electronics

MPP 408: Medical Physics Practical-II (4 hr in a week)

Objective:

To import the practical knowledge, construction and characterisation of electronic circuits used detecting and counting systems.

Outcomes:

Students will be able to construct and verify the functioning of various electronic circuits such as:

- Integrator and differentiator circuits using OPAMP and evaluate their performance
- Construct digital to analog converting circuits and evaluate.
- Constructing pulse shaping and pulse detecting circuits and evaluate their performance.
- Construct binary up and down counting circuits and check their performance.

List of experiments:

1. Integrator and Differentiator using Op-amp.
2. Digital to Analog Convertor (DAC) - R-2R Ladder.
3. Coincident, anti-coincident and electronic pulse detector circuits.
4. Half adder, full adder, half subtractor and full subtractor using basic gates.
5. Multiplexers and Demultiplexers.
6. bit binary up/down counter.
7. Pulse shaping circuits.
8. C++ program to find area and circumference of the circle.
9. C++ program to find area of triangle.
10. C++ program to find the sum of digits of entered number.
11. C++ program to find the sum and average of two numbers.

*** Additional experiments may be included.**

------*****------

Semester – II: Theory

MPH 451: Radiation Detection and Measurement

Teaching hours: Each Unit – 12 h

Objective:

To acquaint the students about the radiation sources, detectors, radiation counting systems, radiation measuring systems and various kinds of radiation instruments used for diagnosis, therapy and radiation safety.

Outcomes:

- Students will be familiar with different kinds of radiation sources including radioisotopes with specific applications in diagnosis and therapy.
- Learn about radiation and radioisotope detection, counting, recording and analysis of the data.
- Acquaint with different kinds of radiation counters and measuring instruments.
- They will also learn about various kinds of personnel monitoring and safety instruments, their operation and use

Unit I: Radiation Sources

Radiation sources - Natural and artificial radioactive sources - Large scale production of isotopes - Reactor produced isotopes - Cyclotron produced isotopes - Fission products - Telecobalt and Brachy Cesium sources – Gold seeds - Tantalum wire - ^{125}I Sources - Beta ray applicators - Thermal and fast neutron sources - Preparation of tracers and labelled compounds - Preparation of radio colloids.

Unit II: Radiation Detection

Principles of Radiation detection and measurement - Basic principles of radiation detection - Counting systems for alpha and beta radiation – Gas Filled detectors, Ionisation chambers - Theory and design - Construction of condenser type chambers and thimble chambers - Gas multiplication - Proportional and GM Counters, Detector efficiency and minimum detectability, Background correction, Geometry correction for counting, Dead time and recovery time - beta spectrometer.

Unit III: Radiation Counters

Scintillation detectors, Characteristics of organic and inorganic scintillators, liquid scintillators, liquid scintillation counting system, quench correction, solid scintillators, NaI(Tl) detector, RIA counters, Semiconductor detector, HPGe detector, Gamma ray spectrometers - single and multi-channel analyzers, Pulse height spectroscopy, Neutron Detectors - Nuclear track emulsions for fast neutrons - Solid State Nuclear track detectors (SSNTD) - New Developments.

Unit IV: Radiation Measuring Instruments

Dosimeters based on condenser chambers - Pocket chambers - Dosimeters based on current measurement - Different types of electrometers - MOSFET, Vibrating condenser and Varactor bridge types - Secondary standard therapy level dosimeters - Farmer Dosimeters – Radiation field analyser (RFA) - Radioisotope calibrator - Multipurpose dosimeter - Water phantom dosimetry systems - Brachytherapy dosimeters - Thermoluminescent dosimeter readers for medical applications - Calibration and maintenance of dosimeters.

Unit V: Radiation Instruments

Instruments for personnel monitoring – TLD, OSLD badge readers - PM film densitometers - Glass dosimeter readers - Digital pocket dosimeters using solid state devices and GM counters - Teletector- Industrial gamma radiography survey meter - Gamma area (Zone) alarm monitors - Contamination monitors for alpha, beta and gamma radiation - Hand and Foot monitors - Laundry and Portal Monitors - Scintillation monitors for X and gamma radiations - Neutron Monitors, Tissue equivalent survey meters - Flux meter and dose equivalent monitors - Pocket neutron monitors – Tele-dose systems. Instruments for counting and spectrometry - Portable counting systems for alpha and beta radiation - Gamma ray spectrometers - Multichannel Analyser - Liquid scintillation counting system - RIA counters – Whole body counters - Air Monitors for radioactive particulates and gases. Details of commercially available instruments and systems.

Reference Books:

1. Nicholas Tsoulfanidis Measurement and Detection of Radiation, second edition
2. W.E. Burcham& M. Jobes – Nuclear and Particle Physics – Longman (1995)
3. G.F.Knoll, Radiation detection and measurements
4. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
5. W.J.Meredith and J.B.Massey “Fundamental Physics of Radiology” John Wright and sons, UK, 1989.
6. J.R.Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
7. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001

------*****------

MPH 452: Radiation Dosimetry and Standardization

Teaching hours: Each Unit – 12 h

Objective:
To acquaint the students with basics of ionising radiation, quantities and their units and to introduce dosimetry and standardisation techniques including familiarizing with radiation chemistry and methods of chemical dosimetry.

Outcomes:

- Students will gain the knowledge regarding radiation, radiation dosimetry, their quantities and units.
- They will understand the about radiation standards, measuring and standardising techniques.
- The students will learn about brachytherapy and standardisation of its sources.
- They will acquaint themselves with neutron standards, dosimetry and measuring equipment.
- Students will understand the importance of standardisation of radionuclides used in diagnosis and therapy and associated instrumentation.
- They will be capable of standardizing the radiation dosimetric systems and measurements.
- Students will be able to achieve safety aspects of radiation by employing proper dosimetric system and measurements.

Unit I: Radiation Quantities and Units

Units of radioactivity: Becquerel, Curie, specific activity, carrier free activity, resonance absorption and Mossbauer Effect. Biological and Effective Hal-Life - Quantities and units: Dose, roentgen unit of exposure, radiation sensitivity of biological materials, Radiation Absorbed Dose (RAD, Gray), radiation weighting factor, Relative Biological Effectiveness (RBE), Quality factors, Roentgen Equivalent Man (REM), Sievert, equivalent dose, effective dose, collective equivalent dose, total effective dose equivalent. Radiometry, Particle flux and fluence, Energy flux and fluence, Cross section, Mass energy transfer and mass absorption coefficients, LET Radiation, chemical yield, W value, Dosimetry – Energy imparted – Absorbed dose, Radiation and tissue weighting, factors, equivalent dose, effective dose, Concepts of collective dose – KERMA-CEMA, Exposure, Air kerma rate constant – Charged particle equilibrium (CPE) – Relationship between kerma, absorbed dose and exposure under CPE, Dose equivalent, Ambient and directional dose equivalents [(H*(d) and H'(d)], individual dose equivalent penetrating Hp(d), Individual dose equivalent superficial Hs(d).

Unit II: Dosimetry & Standardization of X and Gamma Rays Beams

Standards - Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure.Limitations of FAIC.Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation.Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of D_{gas}, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor - N_X, N_K, $N_{D,\ air}$, $N_{D,\ W}$. IAEATRS277: Various steps to arrive at the expression for D_W starting from N_X. TRS398: $N_{D,\ W,\ Q}$: $N_{D,\ W}$: $K_{Q,Q0}$:K_Q , Derivation of an expression for $K_{Q,Q0}$. Calorimetric standards – Inter comparison of standard

Measurement of temperature and pressure. Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. Parallel plate, cylindrical and spherical ion chambers, K_{sat} , Two voltage method for continuous and pulsed beams, Polarity correction. Cross calibration using intermediate beam quality. Quality Audit Programmes in Reference and Non-Reference conditions.

Standardization of brachytherapy sources - Apparent activity - Reference Air Kerma Rate - Air Kerma Strength - Standards for HDR ^{192}Ir and ^{60}Co sources - Standardization of ^{125}I and beta sources, Extrapolation Chambers - IAEA TECDOC 1274 - room scatter correction. Cross calibration of cylindrical ionization chambers – parallel plate ionization chambers – Bell Chamber - Calibration of protection level instruments and monitors.

Unit III: Neutron Standards & Dosimetry

Neutron classification, neutron sources, Neutron standards - primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method.Neutron spectrometry, threshold detectors, scintillation detectors & multi-spheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators – Proportional counter – CR-39 Dosimetry.

Unit IV: Standardization of Radionuclides

Methods of measurement of radioactivity - Defined solid angle and 4π counting - Beta gamma coincidence counting - Standardization of beta emitters and electron capture nuclides with proportional, GM and scintillation counters - Standardization of gamma emitters with scintillation spectrometers - Ionization chamber methods – Extrapolation chamber - Routine sample measurements – Liquid Scintillation counter – Windowless counting of liquid samples - Scintillation counting methods for alpha, beta and gamma emitter - Reentrant ionization chamber methods - Methods using (n, γ) and (n, p) reactions - Determination of yield of neutron sources - Space integration methods - Solid state detectors.

Unit V: Radiation Chemistry and Chemical Dosimetry

Definitions of free radicals and G-value-Kinetics of radiation chemical transformations - LET and dose-rate effects - Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects - Radiation Chemistry of gases and reactions of dosimetry interest - Radiation polymerisation, effects of radiation on polymers and their applications in dosimetry - Formation of free radicals in solids and their applications in dosimetry - Description of irradiators from dosimetric view point - Dosimetry principles - Definitions of optical density, molar absorption coefficient, Beer- Lambert's law, spectrophotometry - Dose calculations - Laboratory techniques - Reagents and procedures - Requirements for an ideal chemical dosimeter - Fricke dosimeter - FBX dosimeter - Free radical dosimeter - Ceric sulphate dosimeter - Other high and low level dosimeters - Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

Reference Books:

1. Joseph Magill and Jean Galy, Radioactivity Radionuclides Radiation,European commission Joint research centre, Institute for TransuraniumElements, P.O.Box 2340, 76125 Karlsruhe, Germany
2. IAEA TRS 374, Calibration of dosimeters used in Radiation Therapy
3. F.H. Attix. Introduction to Radiological Physics and Radiation dosimetry, Viley-VCH, Verlog, 2004
4. Field, clinical use of Radioisotopes.
5. Howard L. A., Radiation Biophysics, Prentice Hall Inc., 1974.
6. Knoll G.E., Radiation detection and measurement, John Wiley and sons, 1979.

------*****------

MPS 453: Fundamentals of Cancer Biology

Teaching hours: Each Unit – 12 h

Objective:

Familiarising the students with the causes and mechanism of cancer induction, diagnosis and staging of cancer and modalities of treatment.

Outcomes:

- Students will learn basics of cancer biology and different processes involved in it and have knowledge regarding the process of cancer initiation, promotion, progression and malignancy.
- They acquire the knowledge in classifying the type of cancer and various risk factors involved development of cancerous cells.
- They will have knowledge of pathogenesis involving infiltration of cancers into lymph nodes and migration of tumour cells into distant organs.
- They will understand the optimisation of therapy techniques.
- They will understand the comprehensive treatment protocols involving multimodal treatment protocols.

Unit I: Basics of Cancer Biology

Definition, Benign Tumours Vs. Malignant Tumours, Nomenclature – definition of neoplasm, Types ofCancer, Common Symptoms, Molecular Hallmarks of Cancer – GrowthSignal Autonomy, Evasion of Growth Inhibitory Signals, Evasion ofApoptosis (Programmed Cell Death), Unlimited Replicative Potential,Angiogenesis (Formation of New Blood Vessels), Invasion andMetastasis, Molecular Basis of Cancer - Cancer Genes (Oncogenes andTumour Suppressor Genes), Carcinogenesis – A Multistep Process,Evidences for Multistage Models of Carcinogenesis.

Cancer Metabolism: Altered Metabolism in Cancer Cells, Energetic ofCell Proliferation, Genetic Events Important for Cancer InfluenceMetabolism, Targeting Caner Metabolism

Unit II: Cancer Classification and Risk Factors

Cancer Classification – TNM Classification - Purpose, Types of Staging,TNM System, Stage Grouping, Other Factors That Can Affect the Stage,Other classification System – FIGO Classification, Special staining tumours – ERPR, Molecular Classification of Cancer

Cancer Risk Factors: Theories of Carcinogenesis, oncogene and antioncogene -Physical, Biological,Chemical - Exogenous and EndogenousCarcinogens, Metabolism of Chemical Carcinogens, DNA AdductFormation, Biological - DNA Viruses and RNA Viruses, Genetic Syndromes, Life Style Factors.

Unit III: Cell Cycle, Apoptosis and Tumorigenesis

Cell cycle - Alterations inPathways Affecting Growth and Proliferation, Mutations NeutralizingStress Responses, Mutations Causing Genetics and Genomic Instability,Cell Cycle and Cancer Therapy; Apoptosis - Molecular Mechanisms(Intrinsic and Extrinsic Pathway), p53 and Apoptosis, Apoptosis andCancer, Apoptotic Pathways and Cancer Therapy, Autophagy(Mechanism, Autophagy in Tumourigenesis, Autophagy Modulation for Cancer Treatment), Necrosis.

Unit IV: Pathophysiology of Cancer

Invasion and Metastasis: Evaluation and Pathogenesis of Metastasis, AnIntegrated Model of Metastasis, Tools of Cell Migration –TumourInvasion, Cell Adhesion, Integrins and Proteases, Intravasation, Transport,Extravasation, Metastatic Colonization, Organ Selectivity of Metastasis,Metalloproteinases Inhibitors (MPIS).

Etiology of Cancer – Physical, Chemical, Biological, hormonal, Hereditary and Immunity – Systemic effects of Neoplasia – Cancer Pattern-incidence in India – Cancer markers for oral cancer – prostate cancer – head and neck – colorectal – cervical, lungs – breast – gastrointestinal cancer – Alpha fetoproteins – carcino-embryonic antigens – leukemia.

Unit V: Cancer Screening and Treatment Modalities

Screening - Definition,Principles, Evaluating Screening Tests, Developing and evaluating a Cancer Screening Programme, Different Kind of Screening Tests,Screening for Specific Types of Cancer, Genetic Counselling; Treatment –Essential Terms, Surgery, Radiation, Chemotherapy, Biological Therapy,Hormone Therapy, Transplantation, Targeted Therapies, Radiolabelled Immunotherapy, Gene Therapy,Other Treatment Methods (Cryosurgery, Laser Therapy, PhotodynamicTherapy, Hyperthermia), Cancer Clinical Trials.

Treatment intent – Curative and Palliative, Cancer Prevention and Public education – Patient Management on treatment – side effects related to radiation dose and chemotherapeutic drug.

Reference Books:

1. Robert A. Weinberg, The Biology of Cancer, Garland Science, 2012
2. Robin Hesketh, Introduction to Cancer Biology, Cambridge University Press, 2013
3. Vincent T. DeVita, Jr., Theodore S. Lawrence, Steven A. Rosenberg, Cancer: Principles and Practice of Oncology, 9th Edition, Lippincott Williams and Wilkins, 2011

------*****------

MPS 454: Biostatistics, Biomathematics & Computers

Teaching hours: Each Unit – 12 h

Objective:

To make the students understand the basic principles and concepts in statistics and to apply various statistical techniquesand hypothesis testing for applications in bioscience. Familiarise the student on the theory, propagation and quantitation of various errors and analysis of variance and equipping themwith all the mathematical skills including preliminary knowledge on concepts such as LAN, WAN, internet protocol, internet interactive communication and World Wide Web,concept of programming etc.

Outcomes:

- The student will understand the basic principal and concepts in statistics and statistical methods and apply the knowledge in data analysis and interpretation of biological data and hypothesis testing.
- The student will learn about various types of errors and its propagation and quantitate the error in their experimental findings.
- The students will be able to perform analysis of variation (ANOVA).
- The student will develop mathematical skill in set theory, determinant, matrix theory differential and integral calculus as well as develop understanding of various mathematical functions.
- They will acquire knowledge on Fourier transform, vector algebra and coordination geometry.
- The students learn the basics of computer and computer operations covering hardware and software, algorithms of micro & mini computers and workstation and also acquire overall concept and knowledge on design principals and theory of network such as LAN, WAN, internet interactive communication, internet protocols, word wide web and programming concepts.

Unit I: Basic Concepts & Descriptive Statistics

Biostatistics terminology, variables in biology, Levels and measurements of biologicaldata, Classification, tabulation and frequency distribution of the data, graphicalrepresentation by histogram. Polygon, Ogive curve and pie diagram.Measures of central tendency [Mean(Arithmetic,Harmonic and Geometric), Median,Mode] Measures of dispersion (Range, quartile deviation, mean deviation, standarddeviation, coefficient of variation), Comparison of two CVs; Skewness; KurtosisElements of probability theory:- axiomatic definition; Addition theorem; Conditionalprobability; Bayes theorem; Random variable; Mathematical expectation probabilitydistribution - binomial, Poisson and normal distribution; Sampling-parameter, statistic andstandard error; Census - sampling methods; Probability and non-probability sampling;Purposive sampling; Simple random• sampling; Stratified sampling. Correlation and regression, Positive and Negative correlation and calculation of Karl-

Peasrsons Co-efficient of correlation, Spearman’s rank correlation, Partial and multiplecorrelation, regression analysis; Sample linear and nonlinear regression; multipleregression, regression equation, Calculation of an unknown variable using regression equation, Probit and logit analysis, Types of estimation, Confidence interval level ofconfidence. Confidence interval estimate of mean and of proportion.

Unit II: Errors in measurements & Statistical Analysis.

Errors, Accuracy, Precision, general theory of Errors, Classification, standard errors.Ways of expression of precision, Accuracy detection of determinates errors, Statisticalanalysis of biochemical data with spread sheet applications, Use of statistical packages,Data management with computerBasic idea of significance test –Hypothesis testing. , Null and alternative hypothesis;Large sample tests(z-test); Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test — testing of single mean;Testing of two sample means using independent t test, paired t test; ANOVA and Chi-Square Tests: One-way and two-way ANOVA – Latin Square tests for association andgoodness of fit; testing linkage; segregation ratio.

Unit III: Biomathematics I

Sets & symbolic logic: Finite set, infinite set, null or void set, subset, Intervals; closedand open, universal set, operations of set. Relations and functions;Power functions &Polynomials, limits and continuity, Arithmetic and Geometric Series, Binomial Theorem.Permutation and combinations;Determinants: Definition, properties associated withdeterminants, Crammer rule condition of consistency, evaluations of 3 x 3 determinants,simultaneous equations and inversion. Interpolation and polynomial fitting.Matrices: Definitions and types of matrices, properties of matrices, addition, subtractionof matrices, matrix multiplication, elementary transformation, Adjointmatrix,inverseofmatrices; matrices manipulations Special square matrices, Determinant of a squarematrix, Inverse of a matrix, rank of a matrix, Eigen vectors and eigen values,diagonalization;Logarithmic and exponential functions, domain and range.2D Coordinate Geometry: Equation of a line, circle, ellipse, parabola, and hyperbola.3Dgeometry: Equation of sphere, cone;Graphical representations: Linear scales, nonlinearscales, Semi logarithmic, triangular, nomography, pictorial presentations.

Unit IV: Biomathematics II

Differential Calculus: Function, Limit, Continuity and Differentiability, Derivative andits physical significance, basic rules for differentiation (without derivation),Differentiation of standard functions, Method of Differentiation, Derivative of simplealgebraic and trigonometric functions , Maxima and Minima, exact and inexactdifferentiation with specific emphasis on thermodynamic properties, partialdifferentiation. Curve sketchingIntegral Calculus: Basic rules for integration (without derivations), definite andindefiniteintegrals,geometric meaning of integration, applications in the biology andchemistry.Solutions to quadratic and cubic equations.Integration of some standardfunctions.Integration by substitution, by parts, by partial fraction.Applications of Integralcalculus in biology.Definite integral. Ordinary differential equations (first order) - example from biology.

Vectors: Vector algebra, coordinate systems, Basic vectors and components, Scalar andvector multiplications, Reciprocal vectors, coordinate transformations.Vectordifferentialcalculus: curves, arc length, tangent, curvature, velocity & acceleration, directionalderivative, transformation of coordinate systems and vector components, divergence andcurl of vector field. Relations & Functions: Linear, periodic, logarithmic, exponential,Quadratic functions. Mapping & Cartesian product.periodic functions and conversion ofdifferent co-ordinate system; Their application in Biology.Partial differential equations: Introduction to partial derivatives & Ordinary DifferentialEquation of the first order. Fourier transform and inverse Fourier transform.

Unit V: Computer fundamentals.

Computer system at a glance processor (CPU, ALU) Memory (ROM, RAM,CACHE data and address bus) Storage, Input & Output devices, Computer peripherals,Binary code and binary system, Algorithms and Flow charts, Software &Hardware,Operating systems (Dos, Windows) Application software's (MS-office) Super computer,Mainframe computers, Mini computers, Micro computers, Workstation, Concept ofmultimedia and its applications. Network concepts (LAN, WAN, MODEM, Fibre OpticsNetwork) and its topology, Network media and hardware.Design and application ofmodern data communication over telephone lines and Digital telephone lines.Internetprotocols HTML, XML, WWW (World wide webs) Internet connectivity, search engines.Interactive communication on Internet, Programming concepts in C^{++}, Introduction toBioperl, Biojava, Bioxml.

Reference Books

1. P. W. Arora, P.K. Malhan (2002), Biostatistics, Himalayas pub. House, Mumbai.
2. P. S. S. SurnderRao and J. Richard (1996), An introduction to Biostatistics, Prentice Hall of India.
3. Manisha Dixit (2000), Internet an Introduction, Tata McGraw-Hill.
4. Timontry J. O'Leary, Linda I. O'Leary (1999), Microsoft windows 98, Tata McGraw Hill.
5. Timothy J. O'Leary, Linda I. O' Leary (2000), Microsoft office-2000, Tata McGraw Hill.
6. Pitter Norton's (1999), Introduction to Computers, Tata McGraw Hill.
7. Campbell R.C. (1974), Statistics for biologist, Cambridge University Press.
8. Bliss C. I.K. (1967), Statistics in biology vol. 1 Mac-Graw Hill.
9. Wardlaw, A.C (1985), Practical Statistics for Experimental biologist.
10. Bailey, (2000), Statistical Method in biology.
11. Daniel Wayle W., Biostatistics (A foundations for analysis in health sciences).
12. Khan, Fundamental of Biostatistics.
13. Lachin, Biostatistical Method.

-----*****------

MPE 455: Industrial Application of Radiation and Radioisotopes

Teaching hours: Each Unit – 12 h

Objective:
To acquaint the students with basic knowledge ofnuclear/radiation physics, measurements, radiation protection and safety,also to familiarize with industrial applications of radiations, radioisotopes and radiation technology.

Outcomes:

- Students will have knowledge of basic nuclear/radiation physics.
- They learn about radiation measurements, quantities and units.
- Familiar with protection from harmful effects of radiation and know about different kinds of personnel monitoring systems.
- Acquire knowledge onnucleonic gauges used in industries and household applications.
- Students will learn about sealed sources applications of in industries and familiar with radiography and its applications.
- They will also gain the knowledge about application of radiation and radioisotopes in oil and gas exploration.

Unit I: Basic Radiation Physics
Atomic and nuclear structure – Rutherford's and Bohr's atomic models, nucleus and its constituents, isotopes, isobars and isomers.Electromagnetic radiation – Ionising and non-ionising radiations. Radioactivity – Radioactive decay, decay constant, half-life, biological half-life, types of ionising radiations (alpha, beta, X-ray and gamma radiations) and radioisotopes. Radiation sources – Natural and artificial radioactive sources.

Unit II: Radiation Measurements, Quantities, Units and Protection
Basic principles of radiation detection - GM detectors, scintillation detectors, semiconductor detectors, solid state nuclear track detectors (SSNTD) and thermo luminescent dosimeters (TLD).Radiation quantities and units – Activity, radiation exposure, absorbed dose, equivalent dose and effective dose. Linear energy transfer (LET). **Radiation protection -** Objectives of radiation protection, committees and regulatory bodies concerned with risk estimates and radiation protection, occupational exposure, as low as reasonably achievable (ALARA), protection of the embryo/fetus, Exposure of members of the public (non-occupational).

Unit III: Industrial Applications

Non-Destructive Testing: automobile industry - thickness of metal sheets, pipeline corrosion; aircraft industry - checking flaws in jet engines; mineral analysis.Sealed source applications: industrial radiography, gauging applications - density, moisture, level, thickness monitoring gauges. Radio tracer techniques: Leak and block detection, flow rate and mixing measurements. Gamma Radiation Processing Plants: sterilization of medical products, irradiation of food materials, treatment of sewage, etc.Enhancing Material Quality: hardening plastics by cross linking, heat resistant wire and cables by irradiation, radiation vulcanisation of natural rubber for better quality. Electrostatic control applications.Oil and Gas Exploration: nuclear well logging, porosity and lithography studies; contour mapping to test wells and mine bores. Smoke detectors.Neutron activation analysis – landmine detection.Particle accelerators.Nuclear reactors.

Reference Books:

1. Hall Eric J. Radiobiology for the radiologist, Lippincott Williams &Wikins, Philadelfia, 1994.
2. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
3. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
4. Edward L. Alphen, “Radiation Biophysics” Academic Press, Second Edition.

------*****------

Semester - II: Practical
RPAD/AERBSuggested List of Practical
Nuclear/Radiation Physics

Objective:

To familiarise and import the practical knowledge on basic concepts of radiation physics and radiation measuring instruments.

Outcomes:

Students will understand and will be able to design and conduct the experiments to test and measure various properties of radiation and parameters during radiation interaction with different materials.

MPP 456: Medical Physics Practical-III (4 hr in a week)

1. Production and attenuation of bremsstrahlung.
2. Range of beta particles by Feather analysis.
3. Backscattering of beta particles and its applications.
4. To study the statistics of radioisotopic measurements and observe the effect of background on the counting statistics.
5. Study of voltage and current characteristics of an ionization chamber.
6. Calibration of survey instruments and pocket dosimeters.
7. Determining the operating voltage and efficiency of a G.M. monitor.
8. Absorption and backscattering of gamma rays - Determination of HVT.
9. To determine the Absorption Coefficient of a given material for β- particles.
10. To study the change in activity of a sample consisting of two independently decaying radioisotopes.
11. Demonstration of liquid scintillation counter.
12. Estimation of energy resolution, calibration and identification of unknown sources using NaI(Tl) gamma-ray spectrometer.
13. Estimation of energy resolution, calibration and identification of unknown sources using HPGe gamma-ray spectrometer.

Additional experiments may be added

-*-*-*-*-*-*-

Semester - II: Practical
RPAD/AERBSuggested List of Practical
Nuclear/Radiation Physics

MPP 457: Medical Physics Practical-IV (4 hr in a week)

Objective:

To import the practical knowledge on various radiation detecting and measuring equipment and also chemical and physics dosimeters used in dosimetry.

Outcomes:

Students will be able to design experiments to use, operate, characterise and measure different parameters using radiation detectors and dosimeters.

List of experiments:

1. Calibration of Thermoluminescent (TL) phosphor.
2. To determine the radiation response of thermo luminescent dosimeter (TLD).
3. Calibration of a TLD personnel monitoring badge and dose evaluation.
4. Measurement of dose distribution using Thermoluminescent Dosimeters (TLD).
5. Determination of half-value thickness (HVT) and linear attenuation coefficient (μ).
6. Determination of plateau and resolving time of a G.M. counter and its application in estimating the shelf-ratio and activity of a beta source.
7. Output measurement of a gamma chamber using Fricke dosimeter.
8. Dose rate measurement of teletherapy machines using FBX dosimeter.
9. Characteristics of a flow counter and beta activity measurement.
10. To determine absorption coefficients of biological tissues with β and γ radioactive sources of different energies.
11. Estimation of efficiency calibration and activity of unknown sources using NaI(Tl) gamma-ray spectrometer.
12. Estimation of efficiency calibration and activity of unknown sources using HPGe gamma-ray spectrometer.

Additional experiments may be added

-*-*-*-*-*-

Semester - II: Practical
RPAD/AERBSuggested List of Practical
Radiation Diagnosis/Medicine/Therapy

MPP 458: Medical Physics Practical-V (4hr in a week)

Objective:

To provide practical knowledge on different equipments used in radiodiagnosis and radiation therapy, their calibration, operation and safety aspects.

Outcomes:

Students will be able to:

- calibrating equipments used for diagnosis and therapy using ionising radiations.
- application and practice of operating protocols of equipments used in diagnosis and therapy.
- preparing treatment planning using ionising radiations.

List of experiments:

1. Calibration of a therapy level dosimeter.
2. Cross calibration of a therapy level dosimeter against calibrated ion chamber.
3. Characteristics of a radiographic film and image.
4. To study the absorption of radiation by solvents and to determine the counting errors originating from sample geometry.
5. Verification of inverse square law using medical linear accelerator.
6. Estimation of Timer Error of HDR Brachytherapy using Ir-192 source.
7. Estimation of Timer Linearity Error of HDR Brachytherapy using Ir-192 source.
8. Teletherapy manual treatment planning procedures for open field for various beam combination, beam modifier and inhomogenity correction.
9. Determining the light field versus radiation field congruence using gafchromic film.

Additional experiments may be added

-*-*-*-*-*-*-

Semester - II: Practical
RPAD/AERBSuggested List of Practical
Radiation Diagnosis/Medicine/Therapy

MPP 459:Medical Physics Practical-VI (4 hr in a week)

Objective:

To provide practical knowledge on various kinds of dosimeters including personnel dosimeters and methods of dose estimation. Also able to plan and execute treatment plan and therapy.

Outcomes:

Students will be able to:

- calibrating equipments used for diagnosis and therapy using ionising radiations.
- designing teletherapy and brachytherapy treatment planning.
- estimation of radiation doses to the patients during diagnosis and treatment.
- application and practice of standard protocols during diagnosis and therapy.

List of experiments:

1. Study of linearity of dose monitoring system of linear accelerator
2. Brachytherapy treatment planning procedures using a computerised radiotherapy treatment planning system
3. Teletherapy treatment planning procedures using a computerised radiotherapy treatment planning system
4. Use of optical densitometer for field profile determination
5. Measurement of entrance and exit doses and evaluation (In-phantom)
6. Cross calibration of a therapy level dosimeter against calibrated ion chamber.
7. Studying the quality index of user beam using Tissue Phantom Ratio (TPR 20, 10).
8. Determining the wedge factor of all photon beams using medical linear accelerator.

Additional experiments may be added

-*-*-*-*-*-

Semester – III: Theory

MPH 501: Clinical Radiation Biology

Teaching hours: Each Unit – 12 h

Objective:

To acquaint the students with the basic mechanism of radiation induced damages at cellular and tissue levels and familiarisingphysical, biological and chemical modification of radiation damage including tumour biology and new modalities of radiotherapy.

Outcome:

- Students will gain the knowledge regarding kinetics of different stages in irradiated cells.
- They will understand the effects of radiation and DNA damages.
- Understand the somatic and genetic effects of radiation, damages to different organs and identify radiation syndromes.
- They will learn about prenatal radiation effectsand enhanced risk of childhood cancers.
- They will also learn tumour biology, transplanted tumour system and radiobiological bases for fractionated radiotherapy.
- They will understand the causes of clinical radio-resistance and overcoming it.
- They will also learn about various kinds radiotherapies and will understand the new modalities of treatment to reduce the normal tissue morbidity

Unit I: Interaction of Radiation with Living Cells

Kinetics of different stages in irradiated cells-physical stage, physicochemical stage, chemical stage, biochemical stage, induction of cellular level damage. Mechanism of direct and indirect action of radiation, radiolytic products of water Critical target in the living cells, evidences for DNA to be the primary target, Nature of the DNA damage Induced by Radiation. Cell lethality, mitotic death, interphase death and apoptosis. Models of Cell survival, Target Theory, its modifications multi target- single hit and single target- multi hit hypothesis, survival curve parameters-Dq, D0, n, slope etc and limitations of target theory, Linear Quadratic Model of cell survival and the mechanistic support to LQ model, Modification of Cell Survival by dose, Dose Rate, Dose Fractionation, repair and recovery, LET, Oxygen, Chemical radioprotectors and sensitizers, Cell Stage, and Hyperthermia.

Law of Bergonie and Tribondeau, mammalian cell sensitivity protocol, classification, Repair and Recovery, Basis of Radiosensitivity of Cells, DNA Content and RadiosensitivityRadiation induced Division delay, biochemical and biophysical changes, Induction of Mutations and Chromosomal Aberrations (CA), Application of CA Analysis in Biodosimetry.

Unit II: Biological Effects of Radiation

Introduction Historical Data Base, Somatic and Genetic Effects, Immediate and Late Effects. Relationship between cellular level damage Deterministic and Stochastic Effects Deterministic effects- Radiation Syndromes: Radiation Sickness (NVD syndrome), Haemopoietic Syndrome, LD50 (60) Dose for human beings G.I. Syndrome, CNS syndrome Damage to Individual Organs. Skin, Eye Lens, Reproductive System, Lungs, Endocrine Glands, Threshold Doses for different effects, dose-effect relationship. Late Damage in Skin, Lung, immune system and Other Organs.

Unit III: Radiation Damage

Prenatal Radiation Effects- prenatal death, neonatal death, malformations, mental retardation and enhanced risk of childhood cancers. Factors modifying radiation damage: acute, protracted and chronic exposure, nature of radiation, dose rate, localized exposure, partial body Vs whole body, internal and external exposures, age and sex. Chronic radiation syndrome.

Stochastic Effects: Radiation Carcinogenesis, mechanisms, Human Data base, latent period, organ sensitivity, dose response relationship, Risk Evaluation from A-Bomb Survivor Data

Genetic Effects: Studies using model experimental systems, doubling dose concept, Genetic Risk Evaluation, Adaptive response, bystander effect, genomic instability

Unit IV: Radiobiological Basis of Radiation Therapy

Tumour Biology, Growth Kinetic Factors, Cell Cycle, Potentially Doubling Time, Volume Doubling Time, Cell Loss Factor, Studies with Transplanted Tumour System.Radiobiological Bases for Fractionated Radiotherapy, Brachytherapy, 4 Rs of Fractionated Radiotherapy, Causes of Clinical Radioresistance and Approaches to Overcome Radioresistance.

Unit V: New Modalities of Radiotherapy

Light Ion Particles, Neutrons, Boron Capture Therapy, Radiolabelled Immunotherapy, Recent Developments, and Bio- Effect Models for Radiotherapy, Strandquist's Cube Root Rule, NSD, TDF, BED Application of LQ Model in Developing Bio-effect Models for Radiotherapy.

Reference Books:

1. Hall Eric J. Radiobiology for the radiologist, Lippincott Williams &Wikins, Philadelfia, 1994.
2. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
3. A LANGE medical book "Basic Radiology" 2nd Edition, The McGrawHill2011
4. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.

------*****------

MPH 502: Physics of Medical Imaging

Teaching hours: Each Unit – 12 h

Objective:
To familiarise the students with different diagnostic techniques and underlying principlesin formation of images using X-Rays, MRI and Ultrasound radiations, also acquainting the image analysis methods in radiotherapy planning.

Outcomes:

- The students will understand the role of radiation interaction with different tissues, their attenuation coefficients andother process involved in forming the radiographic images used in diagnosis.
- They learn about materials and methods used including prime parameters of X-rays in producing clear and quality images. Familiarise with quality assurance programme for diagnostic radiology.
- Students will be familiar with digital X-ray imaging; mammography; computed tomography and their different techniques and applications.
- They will know the details of Magnetic Resonance Imaging (MRI) and its applications including the safety aspects.
- Interaction of ultrasound with body tissue, image formation, and the methods employed in diagnosis including colour Doppler and their applications will be understood.

Unit I: Principles of X-ray Diagnosis & Conventional Imaging

Physical Principle of diagnostic radiology: Interactions of X-rays with human body, differential transmission of X-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique viz. superimposition of overlying structures and scatter, application of contrast media and projections at different angles to overcome superimposition of overlying structures.

Unit II: Radiography techniques

Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection and slices selected for imaging, objectives of radio-diagnosis, patient dose Vs Image quality. Filtration: Inherent and added filters, purpose of added filters, beryllium filters, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolium, molybdenum).

Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, constrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders & collimators), grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique. Intensify screens: Function of intensifying screens, screen function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare earth screens. Radiographic Film: Components of Radiographic Film, physical principle of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.) QA of film developer.

Image quality: Image quality parameters: sources of un-sharpness, reduction of un-sharpness factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution (point spread function (PSF), line spread function (LSF), edge spread function (ESF), modulation transfer function (MTF), focal spot size evaluation. QA of conventional diagnostic X-ray equipment: Purpose of QA, QA protocols, QA test methods for performance evaluation of x-ray diagnostic equipment.

Unit III: Digital X-ray imaging and Computed Tomography

Xero-radiography, mammography, fluoroscopy, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (Principle only), orthopan tomography (OPG), Computed Tomography (CT), QA of CT equipment.

Unit IV: Magnetic Resonance Imaging (MRI)

Magnetic Resonance image – proton density, relaxation time T1 & T2 images – Image characteristics – MRI system components – Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, Computer functions – Imaging process – Image artifacts – MRI safety.

Unit V: Ultrasound Imaging

Interaction of sound waves with body tissues, production of ultrasound – transducers – acoustic coupling – image formation – modes of image display – colour Doppler.

Reference Books:

1. "The Essential Physics of Medical Imaging" Jerrold T Bushberg, Second Edition 2002, LWW.
2. "Introduction to Medical Imaging Physics, Engineering and Clinical
3. Applications" N. Smith and A. Webb 2011,Cambridge University Press

4. W.J. Meredith and J.B. Massey "Fundamental Physics of Radiology" John Wright and Sons, UK, 1989
5. Christensen 'Physics of Diagnostic Radiology' Lea and Febiger – Philadelphia (1990).
6. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981
7. P. Sprawls, Magnetic Resonance Imaging: Principles, Methods and Techniques, Medical Physics Publishing, Madison (2000)
8. Curry,T.S. Dowdey,J.E. Murry,R.C,(1990), Christensen's introduction to the Physics of diagnostic radiology, 4th edition, Philadelphia,Lea&Febiger
9. Bushberg,S.T; Seibert,J.A; Leidholt,E.M&Boone,J.M.(1994), The essential Physics of Medical imaging, Baltimore, Williams & Wilkins.
10. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R. The Physics of Diagnostic imaging
11. Hendee,W.R. &Ritenour,R.(1993) Medical Imaging Physics, 3rd edition
12. Dendy,P.P. &Heaton,B. Physics for diagnostic radiology, 2nd edition
13. Hashemi,R.H. Bradley, W.G;&Lisanti C.J. MRI the basics.
14. RF Farr and PJ Allisy-Roberts Physics for Medical Imaging
15. Sprawls,P; Magnetic resonance imaging principles, methods and techniques

------*****------

MPS 503: Physics of Nuclear Medicine

Teaching hours: Each Unit – 12 h

Objectives

Acquainting the studentswith basic principles of physics involved in production of medical radioisotopes using reactors and cyclotrons. Familiarise the students with diagnosis, therapy and in functional study of organs using radiopharmaceuticals. To make the students understand the physics and operational principal, performance quality control ofinstruments.Provide knowledge on establishing cyclotron, PET Centre and associated laboratories. The students will be thought radiation safety principles and management.

Outcomes:

-
- The student will be acquaint with radioisotopes and nuclear medicine including their characteristics.
- They will learn about emission tomography, PET, SPECT, image formation and image construction.
- The student will learn about the basics of production of radionuclides used in diagnosis, therapy and functional study of organs; their production and preparation of radiopharmaceuticals.
- They will be familiar with in-vivo and in-vitro procedures, including thyroid uptake, RIA IRMA.
- They will learn the physics of PET, cyclotron, radioisotope production concepts.
- They will be acquiring adequate knowledge in preliminary design and planning of radio pharmacy lab, Nuclear Medicine unit, PET Centre, cyclotron centers in hospitals.
- The students will have good knowledge on basic physics, working principle, quality control of various imaging instrument such as rectilinear scanner, gamma camera and other associated equipment.

Unit I: Radionuclides and Radiopharmaceuticals

Therapeutic and diagnostic radionuclides for nuclear medicine and their radiation characteristics, decay scheme specification & specific activity, chemical form of radioisotope for nuclear medicine, (Example 131I, 32P, 153Sm, 90Y, 99mTc, 201Tl etc), ideal requirement of radionuclide used in nuclear medicine, storage and handling of radioisotopes, carrier free radioisotope, Cyclotron production and reactor production of radioisotopes,

Distinction between radionuclide, radiochemical and radiopharmaceuticals, Specific activity, radioactivity Concentration, chemical concentration, Carrier concept (carrier-free, carrier added, no carrier added), Generator based radiopharmaceuticals and cold kits concept: 99mTc generator; transient equilibrium, generator operation, types of 99mTc generator, solvent extraction generator, column generator, Technetium chemistry; Oxidation states, Reduction methods, Hydrolysis, Complexation, etc. 99mTc Specific kits and radiopharmaceuticals. Other common isotope generators, Methods for radio labeling with Tc-99m, few examples of preparation of 99mTc radiopharmaceuticals**.**

Unit II: Emission Tomography

Imaging using radio nuclides, rectilinear scanner, the Anger Camera – Principles of construction, use and maintenance. Different types of Collimators. Basic principles and Problems, Focal planeTomography, Emission Computed Tomography, Single Photon Emission Computed Tomography. Various Image Reconstruction Techniques SPECT, Positron emission tomography(PET), principles of PET imaging, clinical applications.Working of Medical Cyclotron - Various Image Reconstruction Techniques during imageformation such as Back Projection and Fourier based Techniques, IterativeReconstruction method and their drawbacks. Attenuation Correction, ScatterCorrection, Resolution Correction, Other requirements or Sources of Error.

Unit III: In-vitro, In-vivo Procedures

In-vivo Non-imaging procedures: Thyroid Uptake Measurements, Renogram,Life span of RBC, Blood Volume studies, Life span of RBC etc. Generalconcept of Radionuclide imaging and Historical developments.

Gamma Imaging: Other techniques and Instruments; The RectilinearScanner and its operational principle, Basic Principles and Design of the AngerCamera/Scintillation Camera; System components, Detector system andElectronics, Different types of Collimators, Design and PerformanceCharacteristics of the Converging, Diverging and Pin hole Collimator, ImageDisplay and Recording Systems, Digital image Processing Systems, ScanningCamera, Limitation of the Detector System and Electronics.

In-vitro Technique: RIA/IRMA techniques and its principles Physics of PET and Cyclotron: Principles of PET, PET Instrumentations,Annihilation Coincidence Detection, PET Detector and scanner Design, DateAcquisition for PET, Data corrections and Quantitative Aspect of PET,Working of Medical Cyclotron, Radioisotopes produced and theircharacteristics.Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90for palliative treatment. Radiation Synovectomy and the isotopes used.Concept of Delay

Tank and various Waste Disposal Methods used in NuclearMedicine.Planning and Shielding Calculations during the installation of SPECT, PET/CTand Medical Cyclotron in the Nuclear Medicine Department.

Unit IV: Internal Radiation Dosimetry

Difference Compartmental Model; SingleCompartmental Model, Two Compartmental Model with Back Transference,Two Compartmental Model without Back Transference. Classical Methods ofDose Evaluation; Beta particle Dosimetry; Equilibrium Dose Rate Equation,Beta Dose calculation, Specific Gamma Ray constant, Gamma Ray Dosimetry,Geometrical Factor calculation, Dosimetry of Low Energy ElectromagneticRadiation.

MIRD Technique for Dose calculations; Basic procedure and some practicalproblems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction,Specific Absorbed Fraction, Dose Reciproctiy Theorem, Mean Dose per unitcumulative Activity and Problems related to the Dose Calculations. Limitationof MIRD technique.

Unit V: QA of Nuclear Medicine, Room Design and Safety concern

QA in nuclear imaging (scintigraphy), flood phantom.QA of Gamma Camera Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency. Radiation protection measures, nuclear medicine special laboratory procedures. Planning, design and radiation protection of nuclear medicine laboratories and radiopharamcylab for diagnostic and therapeutic procedures: Categories of Nuclear Medicine laboratories (category 1, 2, 3, 4), Equipments and accessories, Staff requirements, shielding requirements in diagnostic and therapy nuclear medicine laboratories. Delay tanks system. Site planning for cyclotron – PET/CT facility.Radiation protection in Cyclotron operation and PET radiopahramcy lab, Radiation protection and design in PET and PET/CT.

QA of Nuclear Medicine equipment;QA in nuclear imaging (scintigraphy), flood phantom.QA of Gamma Camera Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency.

Reference Books:

1. W.H.Blahd, “Nuclear Medicine”, McGraw Hill Co., New Delhi, 1980.
2. H.N.Wagner, “Principles of Nuclear Medicine”, W.B.Saunders Co, London, 1970.

3. Herbert (John) &D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.
4. Ramesh Chandra, “ Nuclear Medicine Physics The Basics Nuclear Medicine Physics: The Basics, 6th Edition” 2004
5. Safety Report Series No. 40 “Applying Radiation Safety Standards in Nuclear Medicine” – IAEA.
6. “ Nuclear Medicine Resources Manual” INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2006.

------*****------

MPS 504: Clinical Aspects of Radiation Therapy

Teaching hours: Each Unit – 12 h

Objective:

To familiarize the students with theoretical models for fractionated radiotherapy and brachytherapy treatment. To familiarise the students with the various radiation sources such as linear accelerators, generation of charged particle beams, brachytherapy techniques such as LDR,HDR, pulsed brachytherapy, permanent implants, manual and remote after-loading techniques. Familiarization with algorithms associated with treatment planning

Outcomes:

- Students will familiarise with physical and biological factors affecting cell survival, tumour growth and regroth.
- They will learn about time and dose fractionation in radiotherapy.
- They will learn about kinds of accelerators used in production of radioisotopes and used in diagnosis and therapy.
- They will understand all aspects of X-ray production and their applications.
- They learn about brachytherapy techniques including high dose, low dose and pulsed dose techniques, their quality assurance and dosimetry.
- They will understand different kinds of algorithms used for treatment planning computations including Monte Carlo based algorithms.

Unit I: Biological Basis of Radiotherapy and Time Dose Fractionation

Physical and biological factors affecting cell survival, tumour regrowth and normal tissue response -Non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle - High LET radiation therapy. Effects on Cancer Cells: Direct, Indirect Effects of Radiation: Introduction, Pathogenesis of Early and Late Radiation Effects, Single and double strand brake.

Time dose fractionation - Basis for dose fractionation in beam therapy - Concepts for Nominal Standard Dose (NSD), Roentgen equivalent therapy (RET) - Time dose fractionation (TDF) factors and cumulative radiation effects (CRE) - Gap correction, Linear and Linear Quadratic models.

Unit II: Particle Accelerators

Particle accelerators for industrial, medical and research applications - The Resonant transformer - Cascade generator - Van De Graff Generator - Pelletron - Cyclotron – Betatron - Synchro-Cyclotron-Linear Accelerator - Klystron and magnetron - Travelling and Standing

Wave Acceleration - Microtron - Electron Synchrotron-Proton synchrotron. Details of accelerator facilities in India.

Unit III: X-ray Generators

Discovery - Production - Properties of X-rays - Characteristics and continuous spectra - Design of hot cathode X-ray tube - Basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes - Rotating anode tubes - Hooded anode tubes - Industrial X-ray tubes - X-ray tubes for crystallography - Rating of tubes - Safety devices in X-ray tubes - Rayproof and shockproof tubes - Insulation and cooling of X-ray tubes - Mobile and dental units - Faults in X-ray tubes - Limitations on loading.

Electric Accessories for X-ray tubes - Filament and high voltage transformers - High voltage circuits - Half-wave and full-wave rectifiers - Condenser discharge apparatus - Three phase apparatus - Voltage doubling circuits - Current and voltage stabilisers - Automatic exposure control - Automatic Brightness Control- Measuring instruments - Measurement of kV and mA - timers - Control Panels - Complete X-ray circuit - Image intensifiers and closed circuit TV systems - Modern Trends.

Unit IV: Brachytherapy

Definition and classification of brachytherapy techniques – surface mould, intracavitary, interstitial and intraluminal techniques. Requirement for brachytherapy sources – Description of radium and radium substitutes – 137 Cs, 60Co, 192 Ir, 125I and other commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques – Low dose rate (LDR), High dose rate (HDR) and pulsed dose rate (PDR) Paterson Parker and Manchester Dosage systems.ICRU 38 and 58 protocols.Specification and calibration of brachytherapy sources – RAKR and AKR – IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line sources Dosimetry formalisms – Sievert integral AAPM TG-43/43U1 and other Dosimetry formalisms.

High dose rate brachytherapy (HDR):High dose rate unit – remote afterloader – applicators – facility design - HDR dosimetry procedures - quality assurance protocol, procedures and program – HDR source calibration

Afterloading technique: Advantages and disadvantages of manual and remote afterloading techniques. AAPM and IEC requirements for remote afterloading brachytherapy equipment.Acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment.ISO requirements and AQ of brachytherapy sources.Integrated brachytherapy unit.

Brachytherapy treatment planning: CT/MR based brachytherapy planning – forward and inverse planning – DICOM image import/export from OT – Record & verification.Brachytherapy treatment for Prostate cancer.Ocular Brachytherapy using photon and beta sources.Intravascular Brachytherapy – classification – sources – dosimetry procedures – AAPM TG 60 protocol – Electronic Brachytherapy (Axxent, Mammosite etc.)

Unit V: Treatment Planning

Scope of computers in radiation treatment planning – Review of algorithms used for treatment planning computations – pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam and brachytherapy – Factors to be incorporated in computational algorithms. Plan optimization – direct aperture optimization – beamlet optimization – simulated annealing – dose volume histograms (DVH) – Indices used for plan comparisons – Hardware and software requirements – beam & source library generation. Networking, DICOM and PACS.Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

Reference Books:

1. Devita, Cancer Principle and Practice of oncology, 7th Edition, 2000.
2. Choa K. S., Clifford, Radiation oncology – management decisions, 1998.
3. Perez et.al., Principles of radiation oncology.
4. J.Dobbset.al., Practical Radiotherapy Planning. 3rd, 1999.
5. Rath GK et.al. Text book of radiation oncology, 1st, 2000.
6. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
7. S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
8. F.A.Attix “Radiation Dosimetry” Vol IIII, Academic press New York, 1985.
9. FahizM.Khan, Treatment Planning in Radiation Oncology, LWW publication, Second Edition.
10. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. “Practical Radiotherapy Planning” Fourth Edition 2009.

------*****------

MPS 505: IPR, Biosafety & Bioethics

Teaching hours: Each Unit – 12 h

Objectives:

To familiarise the students with basics of intellectual property and patent related matters including patent filing procedures, different national and international treaties and educating about biohazards and safety aspects.

Outcomes:

- Students will learn about intellectual property rights and copyright rights.
- They will understand the national and international agreements and treaties.
- They will learn about patents and patent filing procedures.
- They will learn about biohazards and protection and safety aspects from such hazards.
- Students will also learn about bioethical aspects of biotechnological products and social and ethical implications of biological weapons.

Unit I : Introduction to Intellectual Property

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design,Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor inR&D; IPs of relevance to Biotechnology and few Case Studies

Unit II :Agreements and Treaties

History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPOTreaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Unit III : Basics of Patents and Concept of Prior Art

Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional,Divisional and Patent of Addition; Specifications: Provisional and complete; Forms andfees Invention in context of "prior art"; Patent databases; Searching InternationalDatabases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)

Unit IV : Patent filing procedures

National & PCT filing procedure; Time frame and cost; Status of the patent applicationsfiled; Precautions while patenting–disclosure/non-disclosure; Financial assistance forpatenting-introduction to existing schemes, Patent licensing and agreement Patentinfringement- meaning, scope, litigation, case studies

Unit V :Biosafety

Introduction; Historical Background; Introduction to Biological Safety Cabinets; PrimaryContainment for Biohazards; Biosafety Levels; Biosafety Levels of SpecificMicroorganisms; RecommendedBiosafety Levels for Infectious Agents and InfectedAnimals; Biosafety guidelines- Government of India; Definition of GMOs & LMOs;Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications infood and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment;Risk management and communication; Overview of National Regulations and relevantInternational Agreements including; Cartagena Protocol. Bioethics- Ethical implicationsof biotechnological products and techniques.Social and ethical implications of biologicalweapons.

Texts/Reference Books:

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

Important Links:

http://www.w3.org/IPR/

http://www.wipo.int/portal/index.html.en

http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html

www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

http://www.cbd.int/biosafety/background.shtml

http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm

http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

------*****------

MPE 506: Applications of Radiation and Radioisotopes in Health and Agriculture

Teaching hours: Each Unit – 12 h

Objective:
Familiarizing the students withmedical and agricultural applications of radiations, radioisotopes and radiation technology.

Outcomes:
- Students will be aware of origin and sources of radiation and radioactivity.
- They will learn about nuclear reactors and also about nuclear waste and their impact on terrestrial and marine environments.
- Basic understanding, general knowledge and applications of nuclear radiation in health sector will be familiarized. Also learn about various radiation based equipment used in diagnosis and therapy.
- Students will acquire basic knowledge and understanding of application of nuclear radiation and its technology in agriculture.

Unit I: Environmental Radioactivity
Sources of environmental radioactivity – Natural, artificially produced and technologically enhanced radioactivity. The nuclear fuel cycle, nuclear power reactors, types of reactors, low level and high level radioactive waste, reactor accidents. Nuclear explosions: Short-term and worldwide effects. Impact on marine and terrestrial environments, Behaviour of radioactive contaminants in terrestrial environment.

Unit II: Medical Applications
Sterilization of medical products.New drug testing - radioactive tagging; drug delivery and efficiency, Medical Imaging – X-rays, CT, MRI, SPECT& PET scanning. Therapeutic applications - cancers, heart disease, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body, external radiation therapy, internal radionuclide therapy - Brachytherapy, Boron Neutron Capture Therapy (BNCT). Gamma Knife Radiosurgery (Cyber Knife).Nuclear medicine - radio nuclide production and radiopharmaceuticals, tracers in biological substances, radioisotopes tagging for diagnostic or therapeutic purposes.

Unit III: Agricultural applications
Radiotracers - fertilizers uptake, retention and utilization, nutrients and water requirement estimation, mineral and elemental uptake and distribution by plants and crops. Nuclear moisture density gauge – Soil moisture monitoring. Soil sterilization using ionising radiation.Insect pest management – Pesticide residue monitoring in food, soil, ground water and environment. Crop improvement – sterile insect technique (SIT), radiation induce mutations to develop plants resistant to diseases, new crop breeding of improved variety (groundnut and black gram). Food processing and preservation – reducing post-harvest loss,

food preservation, extension of shelf life, irradiation from packaged food, postponing ripening of fruits.Animal diseases and their vectors.Animal production and health.

Reference Books:

1. Hall Eric J. Radiobiology for the radiologist, Lippincott Williams &Wikins, Philadelfia, 1994.
2. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
3. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
4. Edward L. Alphen, “Radiation Biophysics” Academic Press, Second Edition.

------*****------

Semester – III: Practical
RPAD/AERBSuggested List of Practical
Radiation Diagnosis/Medicine/Therapy

MPP 507: Medical Physics Practical-VII (4 hr in a week)

Objective:
To provide practical knowledge on sources of ionising radiations used in diagnosis and therapy, radioisotope uptake and their measurements.

Outcomes:
Students will be able to:

- understand the radiation sources and their production.
- evaluate the radiographic images.
- design and conduct experiments to measure radiation output and their dosimetric evaluation.
- determine radiation dose distribution during diagnosis and therapy.
- calibration and standardisation of equipments used in diagnosis and therapy.

List of experiments:

1. Calibration and use of alanine dosimeter using ESR technique.
2. Preparation and standardization of unsealed sources.
3. Quality assurance of a diagnostic x-ray machine.
4. Evaluation of characteristics of a radiographic image.
5. Study and calibration of thyroid uptake measurement unit.
6. Estimation of absorbed dose of high energy photon beams in water using Linear Accelerator.
7. Estimation of absorbed dose of high energy electron beams in water using Linear Accelerator.
8. Determining the Percentage Depth Dose (PDD) of high energy photon beams using Radiation Field Analyser.
9. Verifying the accuracy of stepping motor in positioning the source at dwell positions in eachchannels.
10. Measurement of output factor for high energy photon beams.
11. Measurement of Applicator Factor using high energy electron beams.
12. Estimation of mechanical and radiation Isocentre shift for collimator using Gafchromic film.

Additional experiments may be added

-*-*-*-*-*-

Semester – III: Practical
RPAD/AERBSuggested List of Practical
Radiation Diagnosis/Medicine/Therapy

MPP 508: Medical Physics Practical-VIII (4 hr in a week)

Objective:
To familiarise students with radiation sources, their integrity and calibration for different applications; radiation contamination; installation of sources and machines; operation, calibration and their use in diagnosis and therapy including treatment planning.

Outcomes:
Students will be able to:

- install, checking the integrity, calibrating and operating the radiation sources and machines.
- perform computerised treatment planning and radiotherapy.
- install equipment used in diagnostic radiology and conducting radiation protection survey.
- conduct survey of radioisotope laboratory and contamination.
- familiar with treatment planning develop the treatment planning.
- radiation source installation and calibration of equipment.

List of experiments:

1. Integrity check and calibration of low activity brachytherapy sources.
2. In-phantom dosimetry of a brachytherapy source.
3. Familiarisation with treatment planning procedure using a computerised radiotherapy treatment planning system.
4. Survey of a radioisotope laboratory and study of surface and air contamination.
5. Radiation protection survey of teletherapy installations.
6. Radiation protection survey of diagnostic radiology installations.
7. Treatment planning of a carcinoma cervix using computerised treatment planning system.
8. Treatment planning of a carcinoma breast using computerised treatment planning system.
9. Treatment planning of a carcinoma whole brain computerised treatment planning system.
10. Checking the uniform distribution of the radioactive material within an encapsulated source and the uniformity of activity by autoradiograph test.
11. Calibration of a HDR Ir-192 Brachytherapy source using well type ionization chamber.

Additional experiments may be added

------*****------

Semester – IV: Theory

MPH 551: Physics of Radiotherapy (Radiotherapy – I)

Teaching hours: Each Unit – 12 h

Objectives:

Students will be familiarised basics, working principlesand operating protocols of instruments used in radiation diagnosis and therapy; also to design, install and calibrate all the instruments including dose monitoring instruments.Acquaint students with the science of phantom and their application in dosimetric studies.

Outcomes:

- Students will acquaint basics and working principles of Low energy and high energy X-ray units, teletherapy cobalt units, medical electron accelerator and medical proton accelerator and associated instruments and components.
- The students will acquire knowledge in source designing, beam collimation, calibration of diagnosis and therapy units, simulation, dose monitoring &dose protocols related to the operation of therapy units.
- Students acquaint with the various phantoms and their application in dosimetry and dosimetric data generation as well as on various scatter factors.
- The students will understand techniques and devices for beam modification and shaping such as wedge fitter, shielding block etc. for appropriate dose delivery as well as better patient dosimetry.
- The students will know the method of electron energy selection, depth dose characterization, homogeneity correction, field shaping etc. and also carrying out the quality assurance in electron therapy beam.

Unit I: Beam Therapy Generators

Description of low kV therapy X-ray Units -Grenz ray therapy-contact therapy, superficial therapy, ortho-voltage, deep therapy– spectral distribution of kV X-rays and effect of filtration – thoraeus filter – output calibration procedure. Mega voltage therapy units: Construction and working of telecobalt units - source design – beam collimation and penumbra – trimmers and breast cones -Beam shutter mechanisms:-Mercury shutter –

pneumatic pressure system – Isocentric gantry - Design and working of medical electron linear accelerators – beam collimation – asymmetric collimator – multileaf collimator – dose monitoring – electron contamination. Basic aspects of proton accelerators - Output calibration of Cobalt-60 gamma rays, high energy x-rays, electron and proton beams using IAEA TRS 398, AAPM TG 51 and other dosimetry protocols. Relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams. Radiotherapy simulator and its applications.CT and virtual simulations.

Unit II: Central axis Dosimetry parameters and Beam Modifying Devices

Phantoms - Tissue equivalent phantoms - Percentage depth doses (PDD), Tissue air ratio (TAR), Back scatter factor/Peak scatter factor (BSF/PSF)– Tissue phantom ratio (TPR) – Tissue maximum ratio (TMR) – Collimator scatter factor, Phantom scatter factor and total scatter factors. Relationship between TAR and PDD and its applications – relationship between TMR and PDD and its applications. SAR, SMR, off axis ratio and Field factor.Build-up region and surface dose.Use of Radiation field analyzer (RFA) in generation of Dosimetric data.

Beam modifying and shaping devices: Wedge filters – design of wedge filters –wedge isodose angle –wedge transmission factor – wedge system- universal, motorized and dynamic wedges –wedge field techniques - shielding blocks - custom blocking – independent jaws –– Tissue compensation – Bolus, design of compensators - skin dose and factors influencing – methods of field separation – field matching.

Unit III: Beamtherapy techniques and patient dosimetry

Treatment planning in beamtherapy –SSD and SAD set ups – two and three dimensional localization techniques – contouring – simulation of treatment techniques – field arrangements – single, parallel opposed and multiple fields – corrections for tissue in homogeneity, correction for contour irregularities and beam obliquity –- integral dose. Arc/rotation therapy and Clarkson technique for irregular fields – mantle and inverted Y fields.Conventional radiotherapy.Treatment time and Monitor unit calculations.

Unit IV: Clinical Electron Beams

Energy specification – electron energy selection for patient treatment – depth dose characteristics (Ds, Dx, R100, R90, Rp, etc.) – beam flatness and symmetry – penumbra – isodose plots – monitor unit calculations – output factor formalisms – effect of air gap and obliquity on beam dosimetry – effective SSD – X-ray contamination – tissue in homogeneities correction – use of bolus and absorbers – adjacent fields separation – field shaping.

Unit V: Quality Assurance of Beam Therapy

Relative merits of electron, neutron, X-ray and gamma ray beams – Neutron capture therapy – heavy ion therapy. Quality assurance in radiation therapy: precision and accuracy in clinical dosimetry – quality assurance protocols for telecobalt, Medical Linear Accelerator and radiotherapy simulators – IEC requirements – acceptance, commissioning and quality control of telecobalt. Portal and in-vivo dosimetry.Electronic portal imaging devices (EPID).

Reference Books:

1. H.E. Johns and Cunningham, The Physics of radiology
2. FaizM.Khan, Roger A. Potish, treatment Planning in radiation Oncology
3. Walter and Miller’s Textbook of Radiotherapy by C.K.Bomford, I.H.kunkler
4. F.A.Attix “Radiation Dosimetry” Vol IIII,
5. Academic press New York, 1985.
6. F.M. Khan “ Physics of Radiation Therapy” 2010 Fourth edition.
7. H.E.Jones, J.R.Cunnigham, “The Physics of Radiology” Charles C.Thomas, NY, 1980.
8. W.R.Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc London, 1981.
9. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
10. S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
11. J.R.Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book, ADAM Hildre, 1981.

------*****------

MPH 552: Radiation Protection, Standards and Safety

Teaching hours: Each Unit – 12 h

Objective:

To familiarise the students withradiation doses, risks, limits and basic concepts of radiation protection. To familiarise the students with the various radiation sources, principles of monitoring and safety aspects in medical use of radiations, also about radioactive waste, its treatment and disposal. To teach the students about radioisotope transportation, safety aspects involved in it, radiation emergencies, legal framework and legislation to be practiced in radiation protection.

Outcome:

- Students will learn about natural and artificial radioactivity and radiation doses due to them. Also know the basic concepts of safety and protection and about ALARA principle.
- They will come to know about principles involved in radiation monitoring and protection.
- They will understand the safety aspects involved in medical uses of radioisotopes and radiations.
- They will know about radiation waste, its safe handling and disposal.
- Students will be learning transportation of radioisotopes, radiation emergencies involved in handling them, legal framework to be practiced while handling them and also about legislation governing the handling of radiation and radioisotopes.

Unit I: Radiation Protection Standards

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – ICRP recommendations – Basic of Radiation Risk and Dose Limits - The system of Radiological Protection – Justification of Practice, Optimisation of protection and individual dose limits – AERB directives on dose limit - concepts of collective dose – Potential exposures, dose and dose constraints – system of protection for intervention – categories of exposures – occupational, public and medical exposures – ALARA principle, factors governing internal exposure – Safe handling of radioactive materials, Radionuclide concentrations in air and water – ALI, DAC and contamination levels.

Unit II: Principles of Monitoring and Protection

Evaluation of external radiation hazards – Effects of distance, time and shielding – shielding calculations – Personnel and area monitoring – Internal radiation hazards – Radio toxicity of different radionuclides and the classification of laboratories – control of contamination – Bioassay and air monitoring – Chemical protection – Radiation accidents – disaster monitoring.

Unit III: Safety in the Medical uses of Radiation

LNT hypothesis - Radiation shielding Inverse Square Law of radiation, Half Value Layers, TVL, Linear Attenuation Coefficient, Mass Attenuation Coefficient – General considerations – Design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories. Evaluation of radiation hazards in medical diagnostic, therapeutic installations – Radiation monitoring procedures – Protective measures to reduce radiation exposure to staff and patients – Radiation hazards in brachytherapy and teletherapy departments and radioisotope laboratories – Particle accelerators Protective equipment – Handling of patients – Waste disposal facilities – Radiation safety during source transfer operations - Special safety features in accelerators, reactors.

Unit IV: Radioactive Waste Disposal

Radioactive Wastes: sources of radioactive wastes – classification of waste – Treatment techniques for solid, liquid and gaseous effluents – permissible limits for disposal of waste – Sampling techniques for air, water and solids – Geological hydrological and metrological parameters – Ecological considerations.

Disposal of radioactive wastes: General methods of disposal – Management of radioactive waste in medical, industrial, agricultural and research establishments.

Unit V: Radioisotopes – transportation, legal framework and Emergencies

Transport of Radioisotopes: Transportation of radioactive substances – Historical background – General packing requirements – Transport documents – Labeling and marking of packages – Regulations applicable for different modes of transport – Transport by post – Transport emergencies – Special requirements for transport of large radioactive sources and fissile materials – Exemptions from regulations – Shipment approval – Shipment under exclusive use – Transport under special arrangement – Consignor's and carrier's responsibilities.

Legislation: Physical protection of sources – Safety and security of sources during storage, use, transport and disposal – security provisions: administrative and technical – security threat and graded approach in security provision. National legislation – Regulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable Safety Codes, Standards, Guides and Manuals – Regulatory Control – Licensing, Inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers (RSO) and Radiation workers – National inventories of radiation sources – Import, Export procedures.

Radiation Emergencies and their Medical Management: Radiation accidents and emergencies in the use of radiation sources and equipment in industry and medicine – Radiographic cameras and teletherapy units – Loading and unloading of sources – Loss of radiation sources and their tracing – Typical accident cases. Radiation injuries, their treatment and medical management – case histories.

Reference Books:

1. Herman Cember. Introduction to Health Physics
2. Atomic Energy Act 1962
3. AERB Radiation Protection Rules 2004
4. ICRP 1990 Recommendation
5. ICRP 2007 Recommendation
6. IAEA Basic safety standards 115, 1997
7. Shapiro T. radiation Protection
8. Mckenzie. Radiation Protection in radiotherapy
9. Mawson C.A. management of Radioactive wastes.
10. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
11. S.P.Yaremonenko, “Radiobiology of Humans and Animals”, MIR Publishers, Moscow, 1988.
12. R.F. Mold “Radiation Protection in Hospitals” Adam Hilger Ltd. Bristol, 1985.
13. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
14. NCRP, ICRP, ICRU, IAEA, AERB Publications.

------*****------

MPS 553: Modern Trends in Radiotherapy (Radiotherapy – II)

Teaching hours: Each Unit – 12 h

Objectives:

To familiarise the students various aspects radiation therapy, different techniques and instruments used in planning radiation therapy and treating the patients.

Outcomes:

- Students will be able to analyse the imaging data and planning the treatment process.
- They will learn about stereotactic radiosurgery and radiotherapy and quality analysis procedures.
- They will learn in detail all the aspects of intensity modulated radiation therapy and quality analysis protocols.
- Students will be able to plan and deliver tumor specific dose using external photon beam.
- Students develop acquaintance with patient positioning guidelines and isocentric setup for radiation therapy.
- Familiarise with all aspects of brachytherapy including planning, dose calculation and treatment.
- Also familiarise with all aspects of electron beam therapy including planning, dose calculation and treatment.

Unit I: Three –dimensional Conformal Radiation Therapy (3DCRT)

Treatment planning process – imaging data – computed tomography – magnetic resonance imaging – image registration – image segmentation –field multiplicity and collimation – plan optimization and evaluation – Doe volume histogram(DVH) – Dose computation algorithms.

Special techniques in radiation therapy: Total body irradiation (TBI) – large field dosimetry – total skin electron therapy (TSET) – electron arc treatment and dosimetry – intraoperative radiotherapy.

Unit II: Advancements in Conformal Radiotherapy

Stereotactic radiosurgery /radiotherapy (SRS/SRT) – cone and mMLC based X-knife – Gamma Knie – immobilization devices for SRS/SRT – dosimetry and planning procedures –

Evaluation of SRS/SRT treatment plans – QA protocols and procedures for X and Gamma Knife units – Patient specific QA. Physical, Planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy.

Intensity modulated radiation therapy (IMRT) : principles – MLC based IMRT – step and shoot and sliding window techniques – Compensator based IMRT – planning process – inverse treatment planning – immobilization for IMRT – dose verification phantoms, dosimeters, protocols and procedures – machine and patient specific QA. Intensity Modulated Arc Therapy (IMAT e.g. Rapid Arc). Image guided Radiotherapy (IGRT) – concept, imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaption, QA protocol and procedures – special phantom, 4DCT. Tomotherapy – principle – commissioning – imaging – planning and Dosimetry – delivery – plan adaptation – QA protocol and procedures.

Unit III: Tumor dose Specification for External Photon Beams

Gross Tumor volume (GTV), Clinical target Volume (CTV), Internal target volume (ITV), Planning Target Volume (CTV) and Organ at risk (OAR) – Treated volume, Irradiated volume, Maximum target Dose, Minimum Target Dose, Mean Target dose, Median Target dose, Modal target dose, Hot spots - ICRU 50 and 62. Patient positioning: general guide lines – XYZ method of isocenter setup.

Unit IV: Brachytherpay Treatment Planning and Dose Calculation

Purposes of Brachytherapy Treatment Planning, Prescription points for vaginal cylinder, T&O, esophagus, endobronchial, and bile duct treatments, Treatment site, disease, prescribed doses, isodoseline/prescription points, isotopes, applicators used, Contrast, markers, skin wires, Target and critical organs, Applicator insertion, T&O implants, total source strength and exposure time (or dose), Seeds alone vs. boost prostate implants, indexer lengths , Catheter numbering in interstitial implants, Use of spacers, ICRU Report 58 Quantities, RTOG 9517, Accelerated Partial Breast Brachytherapy, Differential DVH for Optimized Plan, Simplified analytical solutions (unfiltered line source Sievert integral), Use of classical implant systems(Manchester, Quimby, Paris) for interstitial implants.

Unit V: Electron Beam Therapy Treatment Planning and Dose Calculation

Effects of patient and beam geometry Air gap, Beam obliquity, Irregular patient surface, Internal heterogeneities: bone, fat, lung, air, Dose algorithms, Analytical algorithms (e.g., Fermi-Eyges based pencil beam), Monte Carlo algorithms, Clinical commissioning, Quality assurance of treatment plans, Treatment planning techniques, Energy and field size selection, Bolus: Constant thickness and shape, Collimation: Inserts, skin, internal, Field abutment techniques Photon-electron mixed beams, Special electron treatment techniques, Total skin irradiation, Total limb irradiation, Electron arc therapy, Intraoperative electron therapy, Total scalp irradiation, Craniospinal irradiation, Conformal therapy.

Reference Books:

1. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
2. S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
3. F.A.Attix “Radiation Dosimetry” Vol IIII, Academic press New York, 1985.
1. FahizM.Khan, Treatment Planning in Radiation Oncology, LWW publication, Second Edition
4. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. “Practical Radiotherapy Planning” Fourth Edition 2009
5. “3D Conformal and Intensity Modulated Radiation TherapyPhysics and Clinical Applications” by James A Pondy
6. “Contemporary IMRT Developing Physics and Clinical Implementation”, S. Webb.
7. New Technologies in Radiation Oncology” W. Schlegel ・T. Bortfeld・A.L.Grosu.
8. “The Physics of Conformal Therapy Advances in Technology” by S.Webb
9. A Practial Guide to CT simulation”, by Lowrence Coy.
10. The Physics of Medical Imaging, S.Webb, Medical Science Series, Adam Hilger, Bristol,1984.
11. Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine” HabibZaidi, George Sgouros IOP, Institute of Physics Publishing, Bristol and Philadelphia.

------*****------

MPS 554: Nuclear Reactors, Particle Accelerators, Industrial Applications of Radiation and Environmental Radioactivity.

Teaching hours: Each Unit – 12 h

Objectives:

To import the knowledge on nuclear reactors and their operations, to familiarise the basics of particle accelerators, to create the awareness on industrial applications of radiation and radiation technology and also to familiarise about natural and artificial radioactivity.

Outcomes:

- Students will understand the basics of nuclear reactors and basic principles of physics in their operation.
- They will learn about particle accelerators and their applications in different areas such as health, industry and agriculture sectors.
- Industrial applications of radionuclides and radiation technology will be understood.
- They will be familiarise with environmental radioactivity and their natural and artificial origin.
- Students come to know the Short-term and worldwide effects nuclear explosions and their impact on marine and terrestrial environments

Unit I: Nuclear Reactors

Nuclear fission – Chain reaction: neutron multiplication, multiplication factor - fission chain reaction.Four factor formula, correction for finite size. Thermal utilization factor – homogenous and heterogeneous reactors.Reactor theory - Critical size of a bare homogeneous reactor.Reactor materials – fuel, moderators, reflectors, coolants, structural and cladding materials, control rods, reactor shielding.Reactor types – research reactors and classification, power reactors and classification, breeder reactors.

Unit II: Particle Accelerators

Classification of accelerators – Performance characteristics;Ion sources – discharge type, low voltage, electron oscillation, radiofrequency, duoplasmatron, cyclotron and negative ion sources; special features of ion sources. Electrostatic accelerators – Cockroft-Walton generator – Van de Graaff generator, pelletron accelerators - Tandem accelerators – Cyclic accelerators – Betatron – Microtron – Superconductivity cyclotron – Protron synchrotron – Linear accelerator.

Unit III: Industrial Applications

Industrial applications – Sealed radioactive sources and their applications in industry – industrial radiography, gauging applications and mineral analysis. Radio tracer techniques:

Leak and block detection, flow rate and mixing measurements, Gamma Sterilisation: medical supplies, bulk commodities.

Unit IV: Environmental Radioactivity - Natural

Environmental radioactivity – sources of natural radioactivity, technologically enhanced natural radioactivity, terrestrial and atmospheric radioactivity. Cosmogenic radionuclides.

Unit V: Environmental Radioactivity – Artificial/Manmade

The nuclear fuel cycle, nuclear power reactors, types of reactors, low level and high level radioactive waste, reactor accidents. Nuclear explosions: Short-term and worldwide effects. Impact on marine and terrestrial environments,

Reference Books:

1. S N Ghoshal. Nuclear Physics, S Chand & Comp. Pvt. Ltd. New Delhi
2. Hall Eric J. Radiobiology for the radiologist, Lippincott Williams &Wikins, Philadelfia, 1994.
3. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
4. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
5. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.

------*****------

MPS 555: Research methodology & Communication

Teaching hours: Each Unit – 12 h

Objectives:

To familiarise and to introduce the students for carrying out the research work in a systematic and organised way and acquainting with methodologies of conducting research. Also to equip the students in selecting the research topic, literature survey, writing the proposal and designing and writing research papers and dissertation.

Outcomes:

- Students will understand the concept of research and the processes involved in conducting the research and will be aware of various kinds of research methodologies.
- They will be able to conduct literature survey related to their area of research, preparing the research proposal and designing it.
- They will understand the techniques of data collection and their interpretation.
- They will be able to solve the problems encountered in conducting the research.
- Students will be able to communicate their research outcome to the scientific journals and publishing.
- They will be able to prepare the research dissertation.

Unit I. Introduction to Research: General.

Definition, Research objectives, Research approaches, Significance ofresearch & importance of knowing how research is done; Criteria of good research;Typesof Research: Pure, Applied and Need based research, Variation of Research: Diagnostic,Descriptive, and Exploratory,Research Ethics – Animal ethics; Human ethics;Bio-safety in research: microorganisms studies Scientific methods, components ofscientific methods, Research process, Problem encountered by researchers in India;Personal attributes- Research and scholarship; difference between undergraduate andresearch education: skills habits and attitudes for research; status of research in India;Psychological phases of PhD process; stress point; aims of supervisors; mismatches andproblems; Managing self; empathy; managing relations with your supervisor, colleagues,and supporting staff, listening; assertiveness; Duration andstages of a PhD Process; long term and short goals; time tabling and deadlines;Profession; integrity, objectivity, fairness and consistency; loyalty; plagiarism andresearch ethics; safely. Problem finding and literature survey.

Unit II.Literature survey, Proposal writing and Research Design.

Types of Literature search – use of library, books & journals – internet surfing, gettingpatents and article reprints as a source of literature survey;Review of Literature–Formulation of Hypothesis, Identification and selection of research problems, preparationof research proposal, synopsis.

Need for research design, Important concepts relating todesign, Features of good design; Research designs ; Basic principles of experimental design; Types of researchdesign: Historical design, Descriptive design, case control, cohort, cross sectional,longitudinal; Experimental and modelling skills-Introduction, selection of variables,design matrix, 2-level factorial design, 3-level factorial design, fractional factorial design,analysis of variance, Taguchi methods – orthogonal arrays, signal to noise ratio;Response Surface Methodology, Latest trends in experimental designs.

Unit III.Data Collection Methodologies and Interpretation.

Data collection: Qualitative and Quantitative data, exploratory data analysis; Meaning,Relevance,limitations and cautions.Data Collection methods: Interview; Observation; Questionnaire; Scope of survey based research, Types of surveys – specific, periodic and transactiondriven, Identification of research problem, analysis of research problem, customeridentification, categorization and sampling, planning a survey project–resources, budgetand schedule, preparation of questionnaire – elements of questionnaire, sequencingquestions, question formats; methods of conducting survey, data collection, analysis, andcompilation of survey report,Developing tools – Validity (internal & external), Reliabilityof the tools. Meaning of Interpretations; Techniques of Interpretation, Precautions in Interpretations.

Unit IV Problem Solving and Creativity.

Learning strategy of problem solving; Bacon’s Theorem and Moore’s Law;Creativity Level and styles of thinking;common-sense and scientific thinking; examples.Problem solving strategiesreformulationor rephrasing.Techniques of representation, Logical thinking, division intosub-problems, verbalization. awareness of scale; importance of graphical representation;closed minds; multipleapproaches to a problem analytical vs analogical reasoning, puzzle solving; example;prepared mind, Creative problem solving using Triz Prescriptions; Communication Skills: Reading Skill :Reading tacticsand strategies, Reading purpose and meaning, Reading outcomes, structure of meaning;Writing Skill: Guidelines for effective writing, Writing styles for application withpersonal resume, Business letter and memo including requests, complains, Technicalreport writing, Development of paragraph, Development of story. Listening Skill:Barriers to listening, Effective listening skills, Attending telephone calls, Note-taking;Speaking and discussion Skill: Component of effective talk / presentation, Effectivespeaking skills, Discussion skills.

Unit V. Research Reporting and Scientific Writing.

Definition and kinds of scientific documents – research paper, review paper, bookreviews, thesis, conference and project reports (for the scientific community and forfunding agencies). Publication – role of author, guide, co-authors. Components of aresearch paper – the IMRAD system, title, authors and addresses, abstract,acknowledgements, references, tables and illustrations. Structure, style and contents; Style manuals; Citation styles: Footnotes,references; Evaluation of research, Dealing with publishers – submission of manuscript,ordering reprints. Current trends in scientific research (Advanced countries, Less-Advanced countries and Global);Report writing- Significance of Report writing;Different steps in Report writing; Mechanics and precautions of writing research reports;Layout of the Research project; Types of reports and Oral presentation, Oral and posterpresentation of research papers in conferences/symposia; Preparation of abstracts.Preparation and submission of research project proposals to funding agencies. Structureof Thesis and Content – Preparing Abstracts; Collaborators & Funding - Classification ofInstitutes, Collaborations and collaborators, Funding for research, Computers in research.

Reference Books

1. How to Write and Publish a Scientific Paper ?; Robert A. Day, Barbara Gastel ; 6th edition; Cambridge : Cambridge University ; 2006.
2. Research Methodology Methods and Techniques ;C.R.Kothari; 2nd edition;New AgeInternational;1990 (e-published in 2009).
3. Research Methodology Methods and Statistical Techniques ;Santosh Gupta; New Delhi:Deep& Deep Publications ; 2000.
4. Research Methodology ; Indrayan
5. E.M. Phillips and D.S. Pugh," How to get a Ph.D-a handbook for Ph.D students and their supervisors", Viva books Pvt. Ltd for all scholars irrespective of their disciplines.
6. Hand book of Science Communication, compiled by Antony Wilson. Jane Gregory,
7. Steve Miller, ShirelyEarl.Overseas Press India Pvt. Ltd, New Delhi. First edition 2005

8. G.L Squires," Practical physics", Cambridge University Press, for all scholars except those from Humanities and management Sciences.
9. Peter b Medewar," Advice to a Young Scientist", Pan Books. LONDON. 1979.
10. D C Montgomery, Design and Analysis of Experiments

----------*------------*-----------

Semester - IV: Project Work

MPP 556: Project Work – 10 hrs/week

- - *- - *- -