



Mangalore University
Medical Physics Division

Syllabus for the newly proposed course on
M. Sc. in Medical Physics

[Prepared as per new Regulations governing the Choice Based Credit System
for the Two Years (Four Semester)]

University Science Instrumentation Centre
Mangalore University
Mangalagangothri-574 199
2017-18

**MANGALORE UNIVERSITY
MEDICAL PHYSICS DIVISION**

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

Title and Commencement:

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

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-I candidates) marks in Physics/Mathematics.

(* - this change in entry level eligibility from 45% to 65% for general category and 40% to 60% for SC/ST/Category-I has been made to fulfill the Atomic Energy Regulatory Board (AERB) guidelines/suggestions)

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 Physics programme 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)			Total Credits	Soft Core (4 Credits)			Open Elective (3 Credits)		Total Credits
	No. of courses				Total Credits	No. of courses		No. of course s	Total Credi ts	
	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 Cr	No. Cs	Hrs	Total Cr	No. Cs	Hrs	Total Cr	
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; Crs – Credits; 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 which three are hard core and two are soft core (4 hours per week for each paper and shall carry 4 credits for each paper) and two practical (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**	1 x 5 = 5	100
Grand Total				91	2700

* = Internal Assessment; ** = Viva voce.

Internal assessment:

- i. Theory:** Marks for internal assessment shall be based on 3 compulsory tests. Two of which are objective test (10x2=20 marks) and one descriptive type test (70 marks). Total marks obtained shall be reduced to 30 - the actual component of internal assessment. 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 ($5 \times 4 = 20$ marks).
- b. Part-II:** One question from each unit (internal choice) of the syllabus (there are 5 units) carrying 10 marks ($5 \times 10 = 50$ 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 ($5 \times 4 = 20$ marks).
- b. Part-II:** Eight questions (at least two questions from each unit) carrying 10 marks each of five questions have to be answered ($5 \times 10 = 50$ 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 2016- 2017)

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				Total Credits
				L	P	T	S	
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				Total Credits
				L	P	T	S	
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

Syllabus for M. Sc. in Medical Physics

Semester – I: Theory

MPH 401: Fundamentals of Physics

Teaching hours: Each Unit – 12 h

Unit I: Condensed Matter Physics

States of matter, crystalline and amorphous materials, thin films and nano structures. Luminescence in solids. Free electron theory and band theory: Free electron theory of metals. Density of states. Fermi energy above 0 K. Electronic specific heat. Pauli paramagnetism. Electrical conductivity of metals. Conductors, semiconductors and superconductors.

Absorption processes - Photoconductivity – Photoelectric effect – Photovoltaic effect – Photoluminescence – Thermoluminescence – Fluorescence – Radioluminescence - Phosphorescence - Colour centres – Types of colour centres – F-Centre - Generation of colour centres.

Unit II: Thermodynamics, Optics and Lasers

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

Properties of light, electromagnetic spectrum. Reflection, refraction, total internal reflection of light. Optical fiber and its structure functioning.

LASER, characteristics of laser, diode laser, high power laser, laser applications.

Unit III: Classical and Quantum Statistics

Classical statistics: Boltzmann distribution, calculation of velocities - average and r.m.s velocities. Gibbs' paradox, Sackur - Tetrode equation, partition functions - translational partition function, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems.

Quantum statistics: Bosons and Fermions - Bose-Einstein and Fermi-Dirac distributions – degenerate Fermi and Bose gases - Bose-Einstein condensation - Planck's law of black-body radiation.

Unit IV: Electrodynamics

Maxwell's equations in vacuum, Maxwell's equations inside matter. Uniqueness theorems, separation of variables for Poisson's equation. Relaxation to a stationary state, Propagating plane electromagnetic (EM) wave, decaying plane EM wave. Energy in static electric field, Energy in static magnetic field, Energy stored and transported by EM waves. EM waves at dielectric boundaries: reflection, refraction, EM waves in conductors: inside and at the

boundary. Rectangular waveguides, Circular cylindrical waveguides, Coaxial cable, Cavities. Wave equation for scalar and vector potentials with sources, solving the wave equation with sources. Electric and magnetic fields: radiation components, Radiation energy loss, Radiation from antennas. Multipole expansion, Electric dipole radiation, Magnetic dipole and electric quadrupole radiation.

Unit V: Quantum Mechanics

General formulation of quantum mechanics: Schrödinger wave equation - review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle. Schrödinger's equation for free particle in one and three dimensions - equation subject to forces. Probability interpretation of the wave function, probability current density - normalisation of the wave function, box normalisation, expectation values and Ehrenfest's theorem.

Textbook:

1. Powell and Crassman, 'Quantum Mechanics'(Addison Wesley, 1961)
2. Mathews P M and Venkatesan K, 'A Text Book of Quantum Mechanics' (Tata McGraw Hill, 1977)
3. Ghatak A K and Lokanathan S, 'Quantum Mechanics', III Edn. (McMillan India, 1985)
4. Sakurai J J, 'Modern Quantum Mechanics', Revised Edn. (Addison Wesley, 1994)
5. David J. Griffiths, *Introduction to Electrodynamics*, fourth edition [QC680.G74 2013]
6. Mark A. Heald and Jerry B. Marion, *Classical Electromagnetic Radiation* [QC661.H43 1995]
7. William C. Elmore and Mark A. Heald, *Physics of Waves* [531.33El64P]
8. Davison E. Soper, *Classical Field Theory* [QC174.45.S65 2008]

Reference Books:

1. Cohen Tannoudji C, Diu B and Laloe, 'Quantum Mechanics', Vol. I (John Wiley, 1977)
2. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill, 1968)
3. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
4. French A P and Taylor E F, 'An introduction to Quantum Physics' (W W Norton, 1978)
5. Gasirowicz, 'Quantum Physics' (Wiley, 1974)
6. Wichmann E H, 'Quantum Physics' (McGraw Hill, 1971)
7. V Devanathan, 'Quantum Mechanics', Narosa Publishers
8. Arul Das, 'Quantum Mechanics', New Age Publishers
9. Aggarwal, 'Quantum Mechanics',
- 10.

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

MPH 402: Nuclear and Radiation Physics

Teaching hours: Each Unit – 12 h

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 University 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.Cunningham, "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

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 method - 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 – Lagrange's 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. SrimannarayanaIyengar, 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

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

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 IV: 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 – Santanue Chattopadhyay, 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

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: electric double 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's

Role 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. Bulter I.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. Quagliariello 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. Davis Co.
14. H. H. Perkampus (1992), UV-VIS Spectroscopy and Its applications, Springer-Verlag.
15. Garry D. Christian, James E. O'Reilly (1986), Instrumentation analysis, Alien and Bacon, Inc.
16. S.M. Khopkar (1984), Basic Concepts of Analytical chemistry, Wiley Eastern Ltd.

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

Semester – I: Practical Nuclear/Radiation

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

1. Determination of half-value thickness (HVT) and linear attenuation coefficient (μ)
2. Cross calibration of a therapy level dosimeter against calibrated ion chamber
3. Teletherapy manual treatment planning procedures for open field for various beam combination, beam modifier and inhomogeneity correction
4. Study of timer linearity of radiotherapy equipments – Telecobalt HDRBT
5. Characteristics of a radiographic film and image
6. To study the absorption of radiation by solvents and to determine the counting errors originating from sample geometry.
7. To determine absorption coefficients of biological tissues with β and γ radioactive sources of different energies.
8. To study the change in activity of a sample consisting of two independently decaying radioisotopes.

*** Additional experiments may be included.**

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

1. To study the statistics of radioisotopic measurements and observe the effect of background on the counting statistics.
2. To determine the Absorption Coefficient of a given material for β - particles.
3. Study of linearity of dose monitoring system of linear accelerator
4. Brachytherapy treatment planning procedures using a computerised radiotherapy treatment planning system
5. Teletherapy treatment planning procedures using a computerised radiotherapy treatment planning system
6. To determine the radiation response of thermo luminescent dosimeter (TLD).
7. Demonstration of liquid scintillation counter.
8. Use of optical densitometer for field profile determination
9. Measurement of entrance and exit doses and evaluation (In-phantom)

*** Additional experiments may be included.**

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

Semester – II: Theory

MPH 451: Radiation Detection and Measurement

Teaching hours: Each Unit – 12 h

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 Tsoufanidis Measurement and Detection of Radiation, second edition
2. W.E. Burcham & M. Jobs – Nuclear and Particle Physics – Longman (1995)
3. G.F. Knoll, Radiation detection and measurements
4. Thermoluminescence Dosimetry, Mcknlly, 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. Lowenthal and P.L. Airey, Cambridge University Press, U.K., 2001

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

MPH 452: Radiation Dosimetry and Standardization

Teaching hours: Each Unit – 12 h

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 $[(H^*(d) \text{ and } H'(d))]$, individual dose equivalent penetrating $H_p(d)$, Individual dose equivalent superficial $H_s(d)$.

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 , $N_{D, \text{air}}$, $N_{D, w}$. IAEA TRS277: Various steps to arrive at the expression for D_w starting from N_X . TRS398: $N_{D, w, Q}$: $N_{D, w}$: K_{Q, Q_0} : K_Q , Derivation of an expression for K_{Q, Q_0} . 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 Transuranium Elements, 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, Wiley-VCH, Verlag, 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

Unit I: Basics of Cancer Biology

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

Cancer Metabolism: Altered Metabolism in Cancer Cells, Energetic of Cell Proliferation, Genetic Events Important for Cancer Influence Metabolism, Targeting Cancer 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 Endogenous Carcinogens, Metabolism of Chemical Carcinogens, DNA Adduct Formation, Biological - DNA Viruses and RNA Viruses, Genetic Syndromes, Life Style Factors.

Unit III: Cell Cycle, Apoptosis and Tumorigenesis

Cell cycle - Alterations in Pathways Affecting Growth and Proliferation, Mutations Neutralizing Stress Responses, Mutations Causing Genetics and Genomic Instability, Cell Cycle and Cancer Therapy; Apoptosis - Molecular Mechanisms (Intrinsic and Extrinsic Pathway), p53 and Apoptosis, Apoptosis and Cancer, 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, An Integrated Model of Metastasis, Tools of Cell Migration – Tumour Invasion, 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, Photodynamic Therapy, 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

Unit I: Basic Concepts & Descriptive Statistics

Biostatistics terminology, variables in biology, Levels and measurements of biological data, Classification, tabulation and frequency distribution of the data, graphical representation 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, standard deviation, coefficient of variation), Comparison of two CVs; Skewness; Kurtosis Elements of probability theory:- axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation probability distribution - binomial, Poisson and normal distribution; Sampling- parameter, statistic and standard 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-Pearsons Co-efficient of correlation, Spearman's rank correlation, Partial and multiple correlation, regression analysis; Sample linear and non linear regression; multiple regression, regression equation, Calculation of an unknown variable using regression equation, Probit and logit analysis, Types of estimation, Confidence interval level of confidence. 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, Statistical analysis of biochemical data with spread sheet applications, Use of statistical packages, Data management with computer Basic 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 and goodness of fit; testing linkage; segregation ratio.

Unit III: Biomathematics I

Sets & symbolic logic: Finite set, infinite set, null or void set, subset, Intervals; closed and 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 with determinants, Cramer 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, subtraction of matrices, matrix multiplication, elementary transformation, Adjoint matrix, inverse of matrices; matrices manipulations Special square matrices, Determinant of a square matrix, 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. 3D geometry: Equation of sphere, cone; Graphical representations: Linear scales, nonlinear scales, Semi logarithmic, triangular, nomography, pictorial presentations.

Unit IV: Biomathematics II

Differential Calculus: Function, Limit, Continuity and Differentiability, Derivative and its physical significance, basic rules for differentiation (without derivation), Differentiation of standard functions, Method of Differentiation, Derivative of simple algebraic and trigonometric functions, Maxima and Minima, exact and inexact differentiation with specific emphasis on thermodynamic properties, partial differentiation. Curve sketching Integral Calculus: Basic rules for integration (without derivations), definite and indefinite integrals, geometric meaning of integration, applications in the biology and chemistry. Solutions to quadratic and cubic equations. Integration of some standard functions. Integration by substitution, by parts, by partial fraction. Applications of Integral calculus in biology. Definite integral. Ordinary differential equations (first order) - example from biology.

Vectors: Vector algebra, coordinate systems, Basic vectors and components, Scalar and vector multiplications, Reciprocal vectors, coordinate transformations. Vector differential calculus: curves, arc length, tangent, curvature, velocity & acceleration, directional derivative, transformation of coordinate systems and vector components, divergence and curl of vector field. Relations & Functions: Linear, periodic, logarithmic, exponential, Quadratic functions. Mapping & Cartesian product. periodic functions and conversion of different co-

ordinate system; Their application in Biology. Partial differential equations: Introduction to partial derivatives & Ordinary Differential Equation 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 of multimedia and its applications. Network concepts (LAN, WAN, MODEM, Fibre Optics Network) and its topology, Network media and hardware. Design and application of modern data communication over telephone lines and Digital telephone lines. Internet protocols HTML, XML, WWW (World wide webs) Internet connectivity, search engines. Interactive communication on Internet, Programming concepts in C⁺⁺, Introduction to Bioperl, Biojava, Bioxml.

Reference Books

1. P. W. Arora, P.K. Malhan (2002), Biostatistics, Himalayas pub. House, Mumbai.
2. P. S. S. Surnder Rao and J. Richard (1996), An introduction to Biostatistics, Prentice Hall of India.
3. Manisha Dixit (2000), Internet an Introduction, Tata McGraw-Hill.
4. Timonry 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

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, Philadelphia, 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 Recommended List of Practical

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. Statistics of radioactive counting.
5. Study of voltage and current characteristics of an ionization chamber.
6. Calibration of survey instruments and pocket dosimeters.
7. Construction and calibration of a G.M. monitor.

Additional experiments may be added

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

1. Calibration of a therapy level dosimeter.
2. Calibration of TL phosphor & TLD reader and its use in dose distribution measurements.
3. 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.
4. Output measurement of a gamma chamber using Fricke dosimeter.
5. Dose rate measurement of teletherapy machines using FBX dosimeter.
6. Calibration of a TLD personnel monitoring badge and dose evaluation.
7. Characteristics of a flow counter and beta activity measurement.
8. Calibration of Gamma ray spectrometer [NaI(Tl), HPGe] and identification of unknown sources using multichannel analyser.

Additional experiments may be added

Semester - II: Practical
Soft Core-6: Electronics

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

1. Construction of a voltage multiplier
2. Characteristics of a regulated power pack
3. DC voltage regulator using transistors
4. Feedback amplifier
5. Construction of an oscillator
6. Free running multi-vibrator

Additional experiments may be added

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

1. Integrator and differentiator circuit using OPAMP
2. Simple D/A converter – Ladder type
3. Coincidence and anticoincidence circuits
4. Pulse shaping circuits
5. To study the Electronic pulse detector.
6. To study the Binary up/down counter.
7. To study the diode laser characteristics

Additional experiments may be added

Semester – III: Theory

MPH 501: Clinical Radiation Biology

Teaching hours: Each Unit – 12 h

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- D_q , D_0 , 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 Radiosensitivity Radiation 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, Philadelphia, 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

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, gadolinium, molybdenum).

Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, contrast 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, sensitometric 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 Applications” N. Smith and A. Webb 2011, Cambridge University Press
3. W.J. Meredith and J.B. Massey “Fundamental Physics of Radiology” John Wright and Sons, UK, 1989
4. Christensen ‘Physics of Diagnostic Radiology’ Lea and Febiger – Philadelphia (1990).
5. W.R. Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc. London, 1981
6. P. Sprawls, Magnetic Resonance Imaging: Principles, Methods and Techniques, Medical Physics Publishing, Madison (2000)
7. Curry, T.S. Dowdey, J.E. Murry, R.C., (1990), Christensen’s introduction to the Physics of diagnostic radiology, 4th edition, Philadelphia, Lea & Febiger
8. Bushberg, S.T.; Seibert, J.A.; Leidholt, E.M. & Boone, J.M. (1994), The essential Physics of Medical imaging, Baltimore, Williams & Wilkins.
9. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R. The Physics of Diagnostic imaging
10. Hendee, W.R. & Ritenour, R. (1993) Medical Imaging Physics, 3rd edition
11. Dendy, P.P. & Heaton, B. Physics for diagnostic radiology, 2nd edition
12. Hashemi, R.H. Bradley, W.G. & Lisanti C.J. MRI the basics.
13. RF Farr and PJ Allisy-Roberts Physics for Medical Imaging
14. Sprawls, P; Magnetic resonance imaging principles, methods and techniques

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

MPS 503: Physics of Nuclear Medicine

Teaching hours: Each Unit – 12 h

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 ^{131}I , ^{32}P , ^{153}Sm , ^{90}Y , $^{99\text{m}}\text{Tc}$, ^{201}Tl 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: $^{99\text{m}}\text{Tc}$ generator; transient equilibrium, generator operation, types of $^{99\text{m}}\text{Tc}$ generator, solvent extraction generator, column generator, Technetium chemistry; Oxidation states, Reduction methods, Hydrolysis, Complexation, etc. $^{99\text{m}}\text{Tc}$ Specific kits and radiopharmaceuticals. Other common isotope generators, Methods for radio labeling with $^{99\text{m}}\text{Tc}$, few examples of preparation of $^{99\text{m}}\text{Tc}$ 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 plane Tomography, 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 image formation such as Back Projection and Fourier based Techniques, Iterative Reconstruction method and their drawbacks. Attenuation Correction, Scatter Correction, 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. General concept of Radionuclide imaging and Historical developments.

Gamma Imaging: Other techniques and Instruments; The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera/Scintillation Camera; System components, Detector system and Electronics, Different types of Collimators, Design and Performance Characteristics of the Converging, Diverging and Pin hole Collimator, Image Display and Recording Systems, Digital image Processing Systems, Scanning Camera, 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, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes produced and their characteristics. Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment. Radiation Synovectomy and the isotopes used. Concept of Delay Tank and various Waste Disposal Methods used in Nuclear Medicine. Planning and Shielding Calculations during the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

Unit IV: Internal Radiation Dosimetry

Difference Compartmental Model; Single Compartmental Model, Two Compartmental Model with Back Transference, Two Compartmental Model without Back Transference. Classical Methods of Dose 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 Electromagnetic Radiation.

MIRD Technique for Dose calculations; Basic procedure and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit cumulative Activity and Problems related to the Dose Calculations. Limitation of 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 radiopharmacy

lab 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 radiopharmacy lab, Radiation protection and design in PET and PET/CT.

QA of Nuclear Medicine equipments; 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

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 break.

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 , ^{60}Co , ^{192}Ir , ^{125}I 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 III, 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

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 in R&D; IPs of relevance to Biotechnology and few Case Studies

Unit II : Agreements and Treaties

History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; 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 and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet (EPO), PATENT Scope(WIPO), IPO, etc.)

Unit IV : Patent filing procedures

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

Unit V :Biosafety

Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines- Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartagena Protocol. Bioethics - Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

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/jyrttext.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

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, Philadelphia, 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
Nuclear/Radiation

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

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. Dose output measurement of photon (^{60}Co gamma rays and high energy x-rays) beams used in radiotherapy treatment.
7. Dose output measurement of electron beams used in radiotherapy treatment.
8. Determination of percentage depth dose of photon and electron beams.

Additional experiments may be added

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

1. Integrity check and calibration of low activity brachytherapy sources.
2. AKS/ RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionisation chambers.
3. In-phantom dosimetry of a brachytherapy source.
4. Familiarisation with treatment planning procedure using a computerised radiotherapy treatment planning system.
5. Survey of a radioisotope laboratory and study of surface and air contamination.
6. Absorption and backscattering of gamma rays - Determination of HVT.
7. Radiation protection survey of teletherapy installations.
8. Radiation protection survey of diagnostic radiology installations.

Additional experiments may be added

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

Semester – IV: Theory

MPH 551: Physics of Radiotherapy (Radiotherapy – I)

Teaching hours: Each Unit – 12 h

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 (D_s , D_x , R_{100} , R_{90} , R_p , 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 III,
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

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 University 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

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 – Dose 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 Knife – 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 adaptation, 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 (PTV) 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 set-up.

Unit IV: Brachytherapy 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 III, 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 Therapy Physics 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 Pracial 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

Unit I: Nuclear Reactors

Unit II: Particle Accelerators

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:

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

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

MPS 555: Research methodology & Communication

Teaching hours: Each Unit – 12 h

Unit I. Introduction to Research: General.

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

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

Types of Literature search – use of library, books & journals – Medlines, internet, getting patents and article reprints as a source of literature survey; Review of Literature–Formulation of Hypothesis, Identification and selection of research problems, preparation of research proposal, synopsis. Need for research design, Important concepts relating to design, Features of good design; Research designs ; Basic principles of experimental design - Pre-experimental, CRD and Quasi-Experimental designs; Types of research design: 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 Techniques and Interpretation.

Collection of Data: Primary Data, Meaning of Secondary data, Meaning, Relevance, limitations and cautions. Data Collection methods: Interview; Observation; Questionnaire

Scope of survey based research, Types of surveys – specific, periodic and transaction driven, Identification of research problem, analysis of research problem, customer identification, categorization and sampling, planning a survey project– resources, budget and schedule, preparation of questionnaire – elements of questionnaire, sequencing questions, question formats; methods of conducting survey, data collection, analysis, and compilation of survey report, Developing tools – Validity (internal & external), Reliability of the tools. Meaning of Interpretations; Techniques of Interpretation, Precautions in Interpretations, Data Processing ; Coding, tabulations, classifications.

Unit IV Problem Solving And Creativity.

Thinking processes problem solving and creativity Level and styles of thinking; common-sense and scientific thinking; examples. Problem solving strategies reformulation or rephrasing. Techniques of representation, Logical thinking, division into sub-problems, verbalization. awareness of scale; importance of graphical representation; Creativity - Some definitions, illustrations from day to day life; gift or skill; creative process; requirement of creativity- role of motivation and open v/s closed minds; multiple approaches to a problem analytical vs analogical reasoning, puzzle solving; example; prepared mind, Creative problem solving using Triz Prescriptions for developing creativity and problem solving; Communication Skills: Reading Skill :Reading tactics and strategies, Reading purpose and meaning, Reading outcomes, structure of meaning; Writing Skill: Guidelines for effective writing, Writing styles for application with personal resume, Business letter and memo including requests, complains, Technical report 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, Effective speaking skills, Discussion skills.

Unit V. Research Reporting Scientific Writing.

Definition and kinds of scientific documents – research paper, review paper, book reviews, thesis, conference and project reports (for the scientific community and for funding agencies). Publication – role of author, guide, co-authors. Components of are search paper – the IMRAD system, title, authors and addresses, abstract, acknowledgements, references, tables and illustrations. Structure, style and contents; Style manuals (Chicago, Harvard, Vancouver, APA, MLA); 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 poster presentation of research papers in conferences/symposia; Preparation of abstracts. Preparation and submission of research project proposals to funding agencies. Structure of Thesis and Content – Preparing Abstracts; Collaborators & Funding - Classification of Institutes, 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 Age International; 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, Shirely Earl. 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

- - * - - * - -