MANGALORE UNIVERSITY

MEDICAL PHYSICS DIVISION

M. SC. IN MEDICAL PHYSICS PROGRAMME
Revised Syllabus (September, 2023)

Prepared as per new regulations governing the

Choice Based Credit System (CBCS)

for Two Years (Four Semester) post-graduation programme

Approved by the Atomic Energy Regulatory Board (AERB), Govt. of India

(No. AERB/RSD/Med.Phy/Mangalore-Univ./2018/353 February 13/19, 2018)

Medical Physics Division

Mangalore University, Mangalagangotri-574 199

MANGALORE UNIVERSITY

MEDICAL PHYSICS DIVISION

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

Title and Commencement of the programme

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

Learning objectives of the programme

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

Programme outcomes

- Acquaint with and understand the basic theories and concepts of physics applied in the medical physics discipline.
- Capable of designing, developing and conducting teaching and training programmes related to the medical physics discipline.

- Work as a medical physicist and practice consultancy.
- Ensure radiation protection and safety to both the general public and patients.
- Augmenting national and international radiation emergencies.

Programme specific outcomes

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

Eligibility for admission

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

Duration of the course

i. **Duration**: The duration of Master Degree Programmes shall extend over FOUR 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.

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 undertaking the internship programme 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 the Radiological Safety Officer (RSO) qualifying examination conducted by the Atomic Energy Regulatory Board (AERB) in coordination with the Radiological Physics and Advisory Division (RPandAD), Bhabha Atomic Research Centre (BARC) only on completion of a one-year internship.

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

Highlights of course pattern

i. The M.Sc. in Medical Physics programme shall comprise “Core” and “Elective” courses. The “Core” courses shall further consist of “Hard” and “Soft” core courses. Hard core courses shall have 04 credits, and soft core courses shall also have 04 credits. Further, there shall be two Open Electives carrying 03 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. The student shall study hard core papers compulsorily as the core requirement to complete the programme of M.Sc. in Medical Physics. Soft core papers are elective but related to the programme's discipline. In addition, two open elective papers of 3 credits each shall be offered in the II and III semesters 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 65 % of the total credits; soft core (S) is 35% while the open electives (OE) will have a fixed 6 credits (2 courses with 3 credits each).

Note

First Semester

The first semester consists of 05 theory courses, out of which 03 are hard core, and 02 are soft core (04 hours per week for each paper/course and shall carry 04 credits for each paper/course) and 02 practical courses (both soft cores, each practical course is of 04 hours duration per week and shall carry 02 credits). The students have to attend two laboratory sessions (each of four hours) in a week for practical courses.

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 (three 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 attend four laboratory sessions (Each of four hours) in a week for practical papers. 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 (both hard core, 8 hours per week and each practical course carries 2 credits). The students have to attend two laboratory sessions (each of four hours) in a week for 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 three hard cores and two one soft core (each course is of 4 hours per week and carry 4 credits). There shall be compulsory project work which has to be undertaken by all the students of the fourth semester. The project work is hard core having a duration of 10 hours per week and carrying 05 credits.

Internal assessment

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

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

Project and 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) chosen from the panel of examiners prepared by the BoS and approved by the University. The remaining 30 marks shall be for internal assessment and based on seminars and continuous assessment of the project work.

Theory examination

Hard core and soft core:

i. 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 the University examination. University examination shall be conducted as per the rules and regulations prescribed by the University. The question paper for the University examination is of three hours duration and shall be set as per the model given below:

ii. **Part I:** Six questions (at least one question from each unit) carrying 04 marks, from which five questions have to be answered (5x4= 20 marks).

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

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 the 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 and shall be set as per the model given below:

i. **Part I:** Seven questions (at least two questions from each unit), each carrying 04 marks, out of which 05 questions have to be answered (5x4= 20 marks).

ii. **Part II:** Eight questions (at least two from each unit) carrying 10 marks each, out of which 05 questions have to be answered (5x10= 50 marks). A question may have not more than 03 subdivisions [Ex: 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.

M Sc DEGREE PROGRAMME IN MEDICAL PHYSICS (CBCS)

COURSE PATTERN AND SCHEME OF EXAMINATION

I SEMESTER

Course Code	Description of the Papers	Teaching hrs/week	Credit	Marks		Max Marks
				Exam	IA	
MPH 401	Fundamentals of Physics	4	4	70	30	100
MPH 402	Nuclear and Radiation Physics	4	4	70	30	100
MPH 403	Radiological Mathematics	4	4	70	30	100
MPS 404R1	Radiation Sources, Detection and Measurement	4	4	70	30	100
MPS 405	Basic Electronics and Biomedical Instrumentation	4	4	70	30	100
MPS 406	Biophysics	4	4	70	30	100
MPP 407	Medical Physics Practical – I	4	2	70	30	100
MPP 408	Medical Physics Practical – II	4	2	70	30	100
Note: Any TWO of the soft core theory courses to be opted/offered. Total Credit : 24. Total marks:700						

II SEMESTER

Course Code	Description of the Papers	Teaching hrs/week	Credit	Marks		Max Marks
				Exam	IA	
MPH 451R1	Human Anatomy and Physiology	4	4	70	30	100
MPH 452	Radiation Dosimetry and Standardization	4	4	70	30	100
MPS 453	Fundamentals of Cancer Biology	4	4	70	30	100
MPS 454	Biostatistics, Biomathematics and Computers	4	4	70	30	100
MPE 455	Industrial Application of Radiation and Radioisotopes	3	3	70	30	100
MPP 456	Medical Physics Practical – III	4	2	70	30	100
MPP 457	Medical Physics Practical – IV	4	2	70	30	100
MPP 458	Medical Physics Practical – V	4	2	70	30	100
MPP 459	Medical Physics Practical – VI	4	2	70	30	100
Note : Any ONE of the soft core theory courses to be opted/offered. One open elective will be offered. Total credit : 23 Total marks : 800						

III SEMESTER

Course Code	Description of the Papers	Teaching hrs/week	Credit	Marks		Max Marks
				Exam	IA	
MPH 501	Clinical Radiobiology	4	4	70	30	100
MPH 502	Physics of Medical Imaging	4	4	70	30	100
MPS 503	Physics of Nuclear Medicine	4	4	70	30	100
MPS 504	Clinical Aspects of Radiation Therapy	4	4	70	30	100
MPS 505	IPR, Biosafety and Bioethics	4	4	70	30	100
MPE 506	Applications of Radiation and Radioisotopes in Health and Agriculture	3	3	70	30	100
MPP 507	Medical Physics Practical – VII	4	2	70	30	100
MPP 508	Medical Physics Practical – VIII	4	2	70	30	100
Note : Any TWO of the soft core theory courses to be opted/offered. One open elective will be offered. Total credit : 23 Total marks : 700						

IV SEMESTER

Course Code	Description of the Papers	Teaching hrs/week	Credit	Marks		Max Marks
				Exam	IA	
MPH 551	Physics of Classical Radiotherapy	4	4	70	30	100
MPH 552	Physics of Advanced Radiotherapy	4	4	70	30	100
MPH 553	Radiation Protection Standards and Safety	4	4	70	30	100
MPS 554	Nuclear Reactors, Particle Accelerators, Industrial Applications of Radiation and Environmental Radioactivity	4	4	70	30	100
MPS 555	Research Methodology and Communication	4	4	70	30	100
MPP 556	Project	10	5	70	30	100
Total			21			500
Note : Any ONE of the soft core courses to be opted/offered. Total credit : 21; Total marks : 500						

OVERVIEW OF THE 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 (soft core)	4 hrs each	70 + 30 each	2 x 2 = 4	200
II Semester	3 Theory courses (2 hard core + 1 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 (3 hard core + 1 soft core)	4 hrs each	70 + 30 each	4 x 2 = 8	400
III Semester	4 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 (3 hard core + 1 soft core)	3 hrs each	70 + 30 each	4 x 4 = 16	400
	Project (hard core)		70 + 30 (Viva-voce)	1 x 5 = 5	100
			Grand Total	91	2700

Note : MPH - Hard core papers MPS - Soft core papers,
MPE – Open Elective MPP – Practical papers

Details of Courses and Credits for Four Semesters

Credits				Total Credits
Hard Core	Soft Core	Total	Open Elective	
55 (65%)	30 (35%)	85	6	91

SEMESTER VISE SYLLABUS FOR THEORY AND PRATICAL PAPERS

SEMESTER – I

Course Code	Description of the Papers
MPH 401	Fundamentals of Physics
MPH 402	Nuclear and Radiation Physics
MPH 403	Radiological Mathematics
MPS 404R1	Radiation Sources, Detection and Measurement
MPS 405	Basic Electronics and Biomedical Instrumentation
MPS 406	Biophysics
MPP 407	Medical Physics Practical – I
MPP 408	Medical Physics Practical – II

MPH 401: FUNDAMENTALS OF PHYSICS

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Condensed Matter Physics

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

States of matter - crystalline and amorphous materials. Thin films and nano structures. Conductors, semiconductors and superconductors - qualitative discussion and application in medical physics. Absorption processes - Photoconductivity – Photoelectric effect – Photovoltaic effect – Photoluminescence – Thermoluminescence – Florescence – Radioluminescence- Phosphorescence.

Unit II: Thermal and Magnetic Properties of Solids

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

Unit III: Thermodynamics, Optics and Lasers

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

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

Lasers: Theory and mechanism. Interaction of laser radiation with tissues –Photodynamic therapy. Overview of lasers in medicine – Laser applications in diagnostic radiology, therapeutic radiology and dosimetry. Hazards of lasers and safety measures.

Unit IV: Radio Frequency and Microwave in Medicine

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

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

Unit V: Physics of Ultrasound

Production, properties and propagation of ultrasonic waves - Bioacoustics – Acoustical characteristics of human body - High power ultrasound in therapy –Ultrasound cardiography (UCG) – Doppler effect -Double doppler shift – doppler systems -ultrasonic tomography - principles of uses of ultrasound in imaging and therapy.

Reference Books:

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

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MPH 402: NUCLEAR AND RADIATION PHYSICS

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Basics of Nuclear Physics

General properties of the nucleus and nuclear decay: Constituents of nucleus and their properties. Mass of the nucleus - binding energy. Charge and charge distribution. Size - estimation and determination of the nuclear radius. Nuclear radius from mirror nuclei.

Spin statistics and parity. Magnetic moment of the nucleus, quadrupole moment and their importance in MRI diagnosis.
Nuclear decay – half life, effective half-life, radioactivity equilibrium- transient and secular equilibrium.

Alpha decay - quantum mechanical tunnelling - wave mechanical theory.

Beta decay - apparent non-conservation of mass, energy and spin, non-conservation of parity. Continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay, Fermi - Kurie plot. Detection of neutrino.

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 III: 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 light and heavy charged particles/ions (proton, He-3, C ions). Bragg-Gray curve. Range straggling.

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 V: Principles and basic characteristics of radiation detectors

Basic principles of radiation detection and measurement - Gas Filled detectors- V-I characteristics - Ionization chambers - Theory and design - Gas multiplication - Proportional and GM Counters. Different types of semiconductor detectors (HPGe, SiLi), Solid scintillators: NaI(Tl) and CsI detectors, Liquid scintillation detector, Characteristics of organic and inorganic scintillators, liquid scintillators, quench correction. Solid State Nuclear track detectors (SSNTD), Neutron Detectors

Detector efficiency and minimum detectability, Background correction, Geometry correction for counting, Dead time and recovery time - beta spectrometer.

Thermoluminescent dosimetry (TLD) - process, materials and properties, photon energy dependence, fading, residual TL and annealing for reuse, repeated read out and sensitivity of TLDs. OSLD and film dosimeters – MOSFET.

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 and II (S Chand and 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 Sematand John R AlBright, 'Introduction to Atomic and Nuclear Physics' V Edn. (Chapman and 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 and Sons)
12. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001.
13. F.M Khan : "Physics of Radiation Therapy" Fourth Edition.
14. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
15. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
16. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
17. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc.
18. London, 1981.
19. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.

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MPH 403: RADIOLOGICAL MATHEMATICS

Teaching hours: Each Unit – 12 h

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

Outcomes:

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

Unit I: Probability, Statistics and Errors

Introduction, concepts principle of statistics and statistical techniques: Sample, population, variables -random variable, classification of variables Role of statistics in medicine.

Data: Data classification – Data collection, Data representation. Tabulation – simple tables, frequency table, grouped frequency table. Graphical representation – line graphs (linear and ratio scale) , bar chart, histogram, frequency polygon, pie chart). Pictorial representation.

Theory of Probability: Definition-trial, outcome and event (various evens- mutually exclusive and not exclusive events, independent events etc.), Definition and formula of permutation and combination probability theorems - Addition and multiplication theorem Conditional probability.

Central tendency – Mean- (arithmetic, geometric, harmonic mean), mean of grouped data, assumed mean, Median, Mode, Moments Variance and Standard deviation- frequency data and grouped frequency data, coefficient of variation, standard error of mean.

Errors: Types of errors (random error and systematic error), measure of uncertainty, probable error, Bias, precision, accuracy, Propagation of error-additive and multiplication, error in $Y=f(x)$, exponential function, logarithmic function.

Probability distribution: Binomial distribution, Poisson distribution, Normal distribution -use of Z table, confidence limit, skewers, kurtosis.

Statistical tests of significance and hypothesis testing: Null hypothesis, alternate hypothesis, significant level, critical value, t-distribution and t-test -unpaired t-test, (single sample, two independent samples), paired samples t test (paired samples), use of t-table (one tail and two tail table), F test - F table, Test for variance /consistency, Definition of parametric and Non-parametric statistics - chi-square distribution (goodness of fit, independent sample).

Correlation and regression: Correlation coefficient, scatter diagram, Regression analysis- least square fitting, slope of the regression line,(X on Y and Y on X), regression line equation.

Unit II: Counting and Medical Statistics

Statistics of nuclear counting: Application of Poission statistics in radioactivity counting - statistics of radioactive decay , sample counting eror, background counting error, determination of uncertainty in count rate

Radiation detector performance – Application of Pearson's chi square in performance evaluation of counter, (goodness of fit), Sensitivity (minimum detection limit), Counter efficiency (geometry, sample size, scattering) determination of resolving time (dead time) of counter

Clinical study design: Descriptive and analytical study, experimental and observational study, Clinical trial (preclinical, phase 0-IV and their importance), clinical ethics

Medical decision: Sensitivity, specificity, Disease prevalence, predictive diagnostic values (negative predictive and positive predictive 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.

Numerical Differentiation and Difference Formulas: Gregory Newton's forward and backward difference formulae, Newton's divided difference formula, Lagrange interpolation formula Taylor Series method.

Introduction to numerical quadrature: Newton-Cotes formulae - Trapezoidal rule, Simpson's One-Third rule. Simpson's Three-Eighth rule, Boole rule, Weddle rule.

One-Dimensional Initial-Value Ordinary Differential equations: 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

System of Linear Algebraic Equations: Gauss elimination method – Inversion of a matrix using Gauss elimination method – LU decomposition - Inversion of a matrix using LU factorization - Gauss Seidal method - Gauss Jacobi method.

Roots of Non-linear Equations: Bisection - False position method - Newton Raphson method.

Polynomial Approximation and Interpolation: Gregory Newton's forward and backward difference formula for equal intervals – Divided difference – Properties of divided difference – Newton's divided difference formula – Lagrange interpolation formula for unequal intervals.

Unit V: Computational Tools and Techniques

Computational packages: Basics of Python with data visualization and statistics, Machine learning and artificial intelligence oriented to medical physics, MATLAB/Mathematica and STATISTICA.

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 and sons
3. Band W. Introduction to Mathematical Physics
4. Croxton – elementary statistics
5. Dahlberg G. Statistical Method of medical and biology students
6. Krasnorm.L. Ordinary differential equation
7. N.P. Bali and Dr. N.Ch. Srimannarayana Iyergar, A text book of Engineering Mathematics, Laxmi publications, 2001.
8. S. Chandra, A text book of Mathematical Physics, Narosa Publishing House.

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MPS 404R1: RADIATION SOURCES, DETECTION AND MEASUREMENT

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Radiation Sources

Radiation sources - Natural sources – Ra-226 and Rn-222 sources. Artificial radioactive sources - large scale production of isotopes - Reactor produced isotopes - Cyclotron produced isotopes - Fission products - Telecobalt and Brachy Cesium sources - Tantalum wire - ^{125}I Sources - Beta ray applicators - Thermal and fast neutron sources – Neutron activation sources. Preparation of tracers and labelled compounds - Preparation of radio colloids.

Physical characteristics of the radionuclides used in Radiation Therapy and Nuclear Medicine.

Unit II: 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, pulse height analyser - 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.

Unit III: Radiation Counters

Counting systems for alpha and beta radiation, Construction and operation of GM counting system, Scintillation counting system, liquid scintillation counting system, RIA counters, Semiconductor detector –HPGe counting system (SCA and MCA) multi-channel analyzers, - Nuclear track emulsions for fast neutrons - BF3 and He3 neutron counters. New Developments.

Unit IV: Radiation Measuring Instruments

Construction and working of thimble(cylindrical) plane-parallel chambers, Farmer design of the cylindrical chamber. Different types of electrometers – analog and digital. Secondary standard therapy level dosimeters - Farmer Dosimeters – Radiation field analyser (RFA) - Radioisotope calibrator - Multipurpose dosimeter – Well type ionization chamber for brachytherapy source calibration.

TL/OSL and film dosimetry systems, TL/OSL discs, rods and cubes and readers- calibration and use, Radiographic and Radiochromic films-calibration and use.

Gel dosimetry system – Polymer gel, Fricke gel. Analysis of gel dosimeters using computed tomography, magnetic resonance imaging and optical CT scanner.

Solid state dosimetry system – semiconductor diodes, MOSFETs, diamond dosimeters, Glass dosimeters (radiophotoluminescence dosimeter).

Calibration and maintenance of Radiation Measuring Instruments.

Unit V: Radiation Monitoring Systems

Survey meters and radiation monitors – ion chamber based survey meters – both vented and pressurized ion chambers, Pocket dosimeters.

Teletector - Gamma area (Zone) alarm monitors - Contamination monitors for alpha, beta and gamma radiation - Hand and Foot monitors - Laundry and Portal Monitors – Wholebody counters.

Instruments for personnel monitoring – TL and OSL personnel monitoring badges - extremity dosimeters.

Fast neutron monitors, Tissue equivalent proportional counters (TEPC) - Flux meter and dose equivalent monitors - Pocket neutron monitors. Portable counting systems for alpha and beta radiation – Portable gamma ray spectrometers. Air Monitors for radioactive particulates and gases.

Some of the commercially available instruments and systems

Calibration and maintenance of radiation monitoring instruments.

Reference Books:

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

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MPS 405: BASIC ELECTRONICS AND BIOMEDICAL INSTRUMENTATION

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Fundamentals of Electronics

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

Unit II: Analog Electronics

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

Unit III: Digital Electronics

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

Unit V: Biomedical diagnostic and therapeutic equipment

Diagnostic Equipment: Principal and working of pH meters, Audiometer, Endoscopes, Blood Flow Meters, Pulmonary Function Analyzers, Blood Gas Analyzer, Oximeters, Pressure meter, Thermometer.

Therapeutics Equipment: Cardiac Pace Makers, Defibrillators, Hemodialysis Machines, Short-wave and Micro-wave Diathermy, Ultrasonic Therapy Equipment, Pain relief through Electrical Stimulation, Surgical Diathermy, Biomedical Applications of Laser in Surgery and Therapy. Anesthesia Machine, Hypothermia equipment, Overview of Radiotherapy Equipment, Qualitative explanation of 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.

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MPS 406: BIOPHYSICS

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

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

Chromatography - Basic Concepts of Adsorption and Partition Chromatography, Principle, Experimental set-up, Methodology and Applications of Adsorption and Partition Chromatography methods i.e., Paper Chromatography and Thin Layer Chromatography. Electrophoresis- Principle, Electrophoretic mobility (EPM) estimation, factors affecting EPM, Instrument design and set-up, Methodology and 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 and Diffraction Techniques.

Centrifugation and 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 and 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 and magnitude of cell surface charge, Electric properties of membranes: electric double layer, Poisson-Boltzmann theory of electric double layer. Chloroplast membrane and 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 Rule 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 and 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. and Williams L.E. (1979), Biophysical Science, Prentice-Hall Inc.
2. Bulterl. A.V. And Noble D.Eds. (1976), Progress in Biophysics and Molecular Biology (all volumes) pergamon, Oxford.
3. Casey E.J. (1967), Biophysics, concepts and mechanisms. Affiliated East west press.

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

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PRACTICALS (SOFT CORE)

MPP 407: MEDICAL PHYSICS PRACTICAL-I (4 HR IN A WEEK)

Objective:

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

Outcomes:

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

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

List of experiments:

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

*** Additional experiments may be included.**

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PRACTICAL (SOFT CORE)

MPP 408: MEDICAL PHYSICS PRACTICAL-II
(4 HR IN A WEEK)

Objective:

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

Outcomes:

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

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

List of experiments:

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

*** Additional experiments may be included.**

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SEMESTER VISE SYLLABUS FOR THEORY AND PRATICAL PAPERS

SEMESTER – II

Course Code	Description of the Papers
MPH 451R1	Human Anatomy and Physiology
MPH 452	Radiation Dosimetry and Standardization
MPS 453	Fundamentals of Cancer Biology
MPS 454	Biostatistics, Biomathematics and Computers
MPE 455	Industrial Application of Radiation and Radioisotopes
MPP 456	Medical Physics Practical – III
MPP 457	Medical Physics Practical – IV
MPP 458	Medical Physics Practical – V
MPP 459	Medical Physics Practical – VI

MPH 451R1: HUMAN ANATOMY AND PHYSIOLOGY

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit 1: Basic Biology, Anatomy and Radiographic Anatomy

Structural hierarchy: atoms, molecules, macromolecules, organelles, cells, tissues, organs, systems, human being. Cell structure-cell membrane, cytoplasm, cell nucleus, organelles present in cytoplasm and nucleus.Functions of different organelles - cell membrane, cell nucleus, endoplasmic reticulum, mitochondria, lysosomes, vacuoles centrioles etc.

Molecular composition of the cell-Macromolecules in cells proteins, nucleic acids, carbohydrates and lipids; structural and functional role; cell membrane and transport of materials by passive transport, active transport and facilitated diffusion.

Structure of the genetic material - chromosomes and DNA and DNA replication. Cell Division -mitosis and meiosis; cell differentiation during prenatal development; primitive stem cells and functional cells.Cell Metabolism-Energy synthesis, glycolysis, TCA cycle, oxidative phosphorylation, production of ATP.

Genetic code - Genes, Transcription, Translation -Protein synthesis. Cellular Genetics- Cell Mutation, chromosomal – deletions, translocations and inversions, duplications; and point mutations-transition, transvertion, frame shift.

Germ cell Mutations and Genetic Disorders- Recessive genetic disorders, Dominant genetic disorders and Sex-linked genetic disorders; Multifactorial genetic disorders. Chromosomal genetic disorders- Structural and numerical; Chromosomal deletions, Monosomy and Trisomy, Polyploidy.

Division of Anatomy, Anatomical Organization, Common Terminologies used in Anatomy, Body Cavities and Surface Anatomy of Various Organs and Anatomical Landmarks, Cellular structure and functions, Various Radiological Imaging Techniques: X-Rays, Specials X-Rays such as Barium Swallow, Barium meal, IVU, Lymphangiography, Ultrasound, CT Scans, MRI Scan, PET Scans, Radionuclide Scans. Roentgenographic images: X-Ray: Skull, Chest X-Ray, Pelvis and Extremities; Contrast studies: Barium Swallow, Barium meal follow through, IVU, Angiography. CT: Brain and spinal cord; Head and Neck; Thorax and Abdomen Pelvis and Extrimeties. MRI: Brain and spinal cord; Head and Neck; Thorax and Abdomen Pelvis and Extrimeties. PET CT Scan, Radionuclide Scan.

Unit 2: Circulatory system and Digestive system

Blood and Circulatory System, Structure and Function of Heart, Cardiac dynamics: Blood Pressure and ECG, Composition of Blood, Blood Grouping and Rh typing, Coagulation of Blood, Structure of Digestive Tract, Oral Cavity and Pharynx, Esophagus and Stomach, Liver and Hepatobiliary System and Pancreas, Small intestines and Large Intestines, Rectum and Anal Canal.

Unit 3: Respiratory and Musculoskeletal system

Anatomy of Respiratory System, Structure of Lungs, Physiology of Respiration and Gas Exchange, Lung Volume and Capacity, Muscles and Tendons, Structure and Functions of Muscles, Bones, Joints and Cartilages, Ossification Centre, The Skull, Vertebral Column, Thoracic Cage and Sternum, Pelvis and Extremities.

Unit 4: Genitourinary and Reproductive System

Male Reproductive System: Prostate and Seminal Vesicles; Penis and Testes, Female Reproductive System: Uterus; Ovaries; Tubes; Vagina; Vulva; Breast, Gonads and their function, Menstrual Cycle and its Physiology, Infertility, Reproductive Cycle, Fertilization, Embryology: Germ cells and Prenatal development, Anatomy of Kidney, Ureter, Urinary Bladder and Urethra, Formation and Excretion of Urine, Micturition, Skin and Appendages.

Unit 5: Endocrine system and Nervous system

Division of Endocrine System**,** Pituitary Gland and its function**,** Thyroid Gland and its function**,** Pancreas and its function**,** Adrenal Glands and their function**,** Division of Nervous System**,** Brain: Structure and Function**,** Spinal Cord: Structure and Function**,** Central Nervous System, Autonomous Nervous System**,** Eyes and Physiology of Vision; Nose and Physiology of Smell**,** Ear and Physiology of hearing; Tongue and Physiology of Taste; Skin and Physiology of Touch.

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 and Sons Inc., New York, 2000.
5. Ross and Wilson, "Anatomy and Physiology", Churchill Livingstone; 2005.
6. Campbell: Biology textbook

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MPH 452: RADIATION DOSIMETRY AND STANDARDIZATION

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

UNIT I: Radiation Quantities and Units

Unit of Radioactivity: Becquerel and Curie, Half-life, Mean life, Biological Half –life; Effective Half-life. Kerma and CEMA; Air kerma rate constant; Relationship between Kerma, Exposure and Absorbed Dose.

Radiant energy, Particle Flux; Flux density (fluence rate); Energy Flux, Energy Fluence Rate; Linear attenuation Coefficient (microscopic and macroscopic cross section); Mass attenuation coefficient; Mass energy transfer coefficient; Mass energy absorption Coefficient, roentgen to rad conversion factor (f factor). Stopping power, Transient Charged particle equilibrium (TCPE).

Radiation Quality; Linear Energy Transfer (Restricted and unrestricted); Relative Biological effectiveness (RBE); LET Vs RBE Relationship. Derived Units in Radiation Protection-Radiation Weighting Factor (W_R), Equivalent Dose (H); Tissue Weighting Factor (W_T);

Effective Dose (E). Concept of Collective Dose- Collective Equivalent Dose, Collective Effective Dose (S).

Internal Exposure: Derived Air Concentration (DAC) and Annual Limit Intake (ALI); Committed Absorbed Dose D (τ)**;** Committed equivalent dose H (τ); Committed effective dose E (τ). Operational Quantities in Personnel Monitoring: ICRU Sphere; Ambient dose equivalent, H*(10); Directional dose equivalent, H' (d, Ω); Personal dose equivalent-Penetrating Hp (d) and Superficial Hs (d).

Unit II: Radiation Dosimetry and Standardization

Details of physical parameters used for specifying the strength of brachytherapy sources:Apparent activity, Reference Air Kerma Rate, Air Kerma Strength

Details of Radiological standards available for gamma and beta emitting brachytherapy sources - ionometric standards and calorimetric standards, Salient features of IAEA TECDOC 1274 towards standardization of brachytherapy sources including the details of methods for determination of room scatter correction calibration, ICRU 72 - Dosimetry for beta ray and low energy photons emitting sealed brachytherapy sources.

Methods of measurement of strength of HDR ^{192}Ir and ^{60}Co brachytherapy sources, ^{125}I and ^{103}Pd low energy brachytherapy sources and beta emitting brachytherapy sources.

Methods and procedures of calibration of therapy level instruments - Parallel plate, cylindrical and spherical ion chambers - Cross calibration of therapy level ionization chambers, Quality Audit Programs in Reference and Non-Reference conditions, Brachytherapy source strength measurement using cylindrical and well type ionization chambers

Unit III: Neutron Standards and 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 and multi-spheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators – Proportional counter – CR-39 Dosimetry.

Unit IV: Standardization of Radionuclides

Measurement of radioactivity by 4π counting system, 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.

Extrapolation chambers for measurement of activity from planar sources.

Scintillation counting methods for alpha, beta and gamma emitter. Reentrant ionization chamber (well type chamber) for standardization of radionuclides.

Unit V: Radiation Chemistry and Chemical Dosimetry

Kinetics of radiation chemical transformation-Physical, Physicochemical and Chemical stages; Pattern of Energy deposition - Spurs, Blobs; Short tracks, Branch tracks and Delta rays; Radiochemistry of water- Formation of Free radicals, Ionic and Molecular reactive species; Primary and Recombination Reactions.

Nature of chemical changes brought about by reactive species - Oxidation; Reduction; Dissociation; Rearrangement; Recombination etc.

Radiation chemical yield (G Value); G value for chemical systems, proteins, amino acids an Enzymes; Gases; Factors affecting G values.

Chemical Dosimetry Systems based on Liquids, Solids and Gases.

UV and Visible Spectrophotometric technique in liquid dosimetry systems - Beer Lambert's Law, molar extinction coefficient, Dose Rate calculation based on OD/min.

Fricke Dosimetry-mechanism of Fe^{++} Oxidation, G value, Dose Range, modification by oxygen, Organic impurities Effect of pH on the yield of various reactive species. Ceric Sulphate - Cerous Sulphate Dosimetry System - Reactions, dose range, G values FBX Dosimeter - Mechanism, dose Range and applications in low dose measurements.

Practical methods of Fricke and FBX Dosimetry

Gaseous System - Nitrous Oxide system Solid State Dosimeters - Alanine Dosimeter, PVC based dosimeter, Dyed Perspex dosimeter, Lithium Fluoride Photo Luminescent Film Dosimeter, Optichromatic Dosimeters, Cellulose Triacetate Film.

Radiation Chemistry of Radiosensitization and Radiation Protection in Biological Systems.

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, Viley-VCH, Verlog, 2004
4. Field, clinical use of Radioisotopes.
5. Howard L. A., Radiation Biophysics, Prentice Hall Inc., 1974.
6. Knoll G.E., Radiation detection and measurement, John Wiley and sons, 1979.

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MPS 453: FUNDAMENTALS OF CANCER BIOLOGY

Teaching hours: Each Unit – 12 h

Objective:
Familiarizing the students with the causes and mechanism of cancer induction, diagnosis and staging of cancer and modalities of treatment.

Outcomes:

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

Unit I: Basics of Cancer Biology
Biokinetics Parameters of Tumours- Physiological Compartments-Proliferating; Quiescent; Differentiated (Sterile); Necrotic cells; Hypoxic cells. Cell cycle time Tc; Labelling Index (LI); Mitotic Index; Growth Fraction; Potentially doubling time Tp and Volume doubling time Td; Cell loss factor; Relationship between various biokinetic parameters.

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 Caner Metabolism

Unit II: Cancer Staging, 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

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MPS 454: BIOSTATISTICS, BIOMATHEMATICS AND COMPUTERS

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Basic Concepts and 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- Pearson's Co-efficient of correlation, Spearman's rank correlation, Partial and multiple correlation, regression analysis; Sample linear and nonlinear 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 and 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 and 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 andPolynomials, limits and continuity, Arithmetic and Geometric Series, Binomial Theorem. Permutation and combinations; Determinants: Definition, properties associated with determinants, Crammer rule condition of consistency, evaluations of 3 x 3 determinants, simultaneous equations and inversion. Interpolation and polynomial fitting. Matrices: Definitions and types of matrices, properties of matrices, addition, 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.3Dgeometry: 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 and acceleration, directional derivative, transformation of coordinate systems and vector components, divergence and curl of vector field. Relations and Functions: Linear, periodic, logarithmic, exponential, Quadratic functions. Mapping and Cartesian product. periodic functions and conversion of different co-ordinate system; Their application in Biology. Partial differential equations: Introduction to partial derivatives and 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 and Output devices, Computer peripherals, Binary code and binary system, Algorithms and Flow charts, Software and 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. SurnderRao and J. Richard (1996), An introduction to Biostatistics, Prentice Hall of India.
3. Manisha Dixit (2000), Internet an Introduction, Tata McGraw-Hill.
4. Timontry J. O’Leary, Linda I. O’Leary (1999), Microsoft windows 98, Tata McGraw Hill.
5. Timothy J. O’Leary, Linda I. O’ Leary (2000), Microsoft office-2000, Tata McGraw Hill.
6. Pitter Norton’s (1999), Introduction to Computers, Tata McGraw Hill.
7. Campbell R.C. (1974), Statistics for biologist, Cambridge University Press.
8. Bliss C. I.K. (1967), Statistics in biology vol. 1 Mac-Graw Hill.
9. Wardlaw, A.C (1985), Practical Statistics for Experimental biologist.
10. Bailey, (2000), Statistical Method in biology.
11. Daniel Wayle W., Biostatistics (A foundations for analysis in health sciences).
12. Khan, Fundamental of Biostatistics.
13. Lachin, Biostatistical Method.

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MPE 455: INDUSTRIAL APPLICATION OF RADIATION AND RADIOISOTOPES

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Basic Radiation Physics

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

Unit II: Radiation Measurements, Quantities, Units and Protection

Basic principles of radiation detection - GM detectors, scintillation detectors, semiconductor detectors, solid state nuclear track detectors (SSNTD) and Thermoluminescent 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 andWikins, Philadelfia, 1994.
2. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
3. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
4. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.

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PRACTICAL (HARD CORE)
MPP 456: MEDICAL PHYSICS PRACTICAL-III
NUCLEAR/RADIATION PHYSICS
(4 HR IN A WEEK)

Objective:

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

Outcomes:

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

List of experiments:

1. Verification of inverse square law using gamma source (GM counter).
2. Measurement of half value thickness (HVT), tenth value thickness (TVT) and evaluation of mass absorption coefficient (NaI(Tl) detector).
3. Study of linearity and determination of unknown dose given to a sample by graphical method (TLD).
4. Chemical etching of cellulose nitrate based LR-115 solid state nuclear track detectors (SSNTDs) and counting of alpha tracks using spark counter.
5. Familiarization of NaI(Tl) gamma spectrometer system.
6. Determination of efficiency for different gamma energies and calculation of activity of unknown sources using NaI(Tl) gamma-ray spectrometer.
7. Determination of efficiency and minimum detectable activity of alpha counting system.
8. Determination of efficiency and minimum detectable activity of low background beta counting system.
9. Study of the characteristics of a GM tube (Determination of the operating voltage).
10. Determination of range of beta particles by Feather analysis (GM counter).
11. Backscattering of gamma rays (NaI(Tl) detector).
12. Familiarization of α-spectrometer system.
13. Familiarization of different types of gamma survey meters.

Additional experiments may be added

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PRACTICAL ((HARD CORE)

MPP 457: MEDICAL PHYSICS PRACTICAL-IV

NUCLEAR/RADIATION PHYSICS
(4 HR IN A WEEK)

Objective:

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

Outcomes:

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

List of experiments:

1. Production and attenuation of Bremsstrahlung (GM counter).
2. Determination of unknown dose given to a sample using the reader factor (TLD).
3. a. Study of gamma spectra of Cs-137 and Co-60 using single channel analyzer (NaI(Tl) detector).

   b. Study of gamma spectra of Cs-137 and Co-60 using multichannel analyzer (NaI(Tl) detector).
4. Familiarization of HPGe gamma spectrometer system.
5. Study of energy resolution, energy calibration, and identification of unknown isotope using HPGe gamma-ray spectrometer.
6. Comparison of active radon monitors inside the radon calibration chamber and outdoor conditions.
7. Fricke dosimeter – Preparation and determination of gamma dose.
8. Locating the lost/misplaced radiation sources using gamma survey meter.
9. Determination of efficiency of a Silicon surface based alpha detector and activity calculation.
10. Determination of efficiency of the Liquid scintillation counting system and activity of a sample.
11. Study of energy calibration, resolution as a function of gamma ray energy for given set of gamma sources (NaI(Tl) detector) and identification of unknown gamma source.
12. Determination of efficiency for a known gamma source and activity of unknown gamma isotope using HPGe detector.

Additional experiments may be added

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PRACTICAL (HARD CORE)

MPP 458: MEDICAL PHYSICS PRACTICAL-V

RADIATION DIAGNOSIS/MEDICINE/THERAPY (4HR IN A WEEK)

Objective:

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

Outcomes:

Students will be able to:

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

List of experiments:

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

Additional experiments may be added

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PRACTICAL (SOFT CORE)

MPP 459: MEDICAL PHYSICS PRACTICAL-VI

RADIATION DIAGNOSIS/MEDICINE/THERAPY
(4 HR IN A WEEK)

Objective:

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

Outcomes:

Students will be able to:

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

List of experiments:

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

Additional experiments may be added

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SEMESTER VISE SYLLABUS FOR THEORY AND PRATICAL PAPERS

SEMESTER – III

Course Code	Description of the Papers
MPH 501	Clinical Radiobiology
MPH 502	Physics of Medical Imaging
MPS 503	Physics of Nuclear Medicine
MPS 504	Clinical Aspects of Radiation Therapy
MPS 505	IPR, Biosafety and Bioethics
MPE 506	Applications of Radiation and Radioisotopes in Health and Agriculture
MPP 507	Medical Physics Practical – VII
MPP 508	Medical Physics Practical –VIII

MPH 501: CLINICAL RADIOBIOLOGY

Teaching hours: Each Unit – 12 h

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

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

Unit I: Cellular Radiobiology

Kinetics of induction of radiation damage in cells: Physical, physicochemical, chemical and biological stages.

Mechanisms of induction of radiation damage: Direct mechanism and indirect mechanisms mediated by chemically reactive species generated by radiolysis; Radiochemistry of water, formation of free radicals, reactive oxygen species and mechanism of induction of reactive species.

Critical target for the induction of radiation damage: Evidence for the role of DNA as critical target, Radiosensitivity and interface chromosome volume; DNA content Vs Radiosensitivty; Suicide experiments with S-35 Vs P-32.

Nature of the damage induced in DNA molecule: Single strand breaks (SSB), Double strand breaks (DSB), Base damage, Crosslinking-intramolecular and intermolecular.

Chromosomal damage: Induction of chromatid and chromosome breaks, formation of aberrant chromosomes; deletions, dicenrics, rings, translocations, inversions.

Applications of chromosomal damage in biodosimetry of radiation exposure: Dicentric assay, Micronucleus assay and premature chromosomal condensation assay using peripheral human lymphocytes.

Mechanisms of induction of cell lethality: Interphase death, reproductive death (mitotic death), programmed cell death (apoptosis), cell necrosis.

Cell radiation response: cell killing, mutations, division delay biophysical and biochemical changes.

Cell survival assay in vitro and in vivo assay: colony forming assay and cell survival curves for mammalian cells.

Lea's Target theory of cell survival: simple target theory, multi target single hit theory, multi target multi hit theory and single target multi hit theory; survival curve parameters-extrapolation number(n); Quasi threshold dose (Dq); mean lethal dose (D_0) and slope; Target size calculation based on simple target theory; Limitations of Target Theory.

Linear quadratic (LQ) model of cell survival, α and β components of cell killing,

α/β value, mechanistic bases of LQ model.

Unit II: Factors modifying cellular response

Physical Modifiers: Dose, Dose rate, Radiation quality, Dose fractionation, Hyperthermia.

Dose rate effect for cell survival and chromosomal damage, modification of β component with the duration of irradiation, dose rate and repair.

Dose fractionation: Elkind and Suttons Recovery, Repair of sublethal damage,

Kinetics of repair, molecular mechanism of repair, effect of dose fractionation on survival response curve.

Radiation quality: Dose response for radiations of different LET, Relative biological effectiveness (RBE), RBE –LET relationship for cell survival and chromosomal aberrations.

Chemical Modifiers: Oxygen - Radiosensitization by oxygen, Oxygen Enhancement Ratio (OER), Variation of OER with Oxygen concentration, Howard-Flanders Equation, Mechanism of oxygen effect, Role of electronegativity and formation of reactive oxygen species, Variation of OER with radiation quality (LET), Importance of hypoxia in Radiotherapy; BUdR, Oxygen mimics, Hypoxic cell sensitizers (Nitroimidazole derivatives).

Chemical radioprotectors, aminothiols - cystamine AET, MEG, WR2721 etc.; Mechanism of radioprotection; Modification by Repair inhibitors.

Biological modifiers: Repair of sublethal and potentially lethal damage; Genetic composition and repair deficient mutations; Mammalian cell sensitivity protocol- Law of Bergonie and Tribondeau; Cell cycle sensitivity variations; DNA content and sensitivity variation between species.

Unit III: Biological Effects of Radiation

Historical data base on the radiation effects seen in human beings; Early classification: somatic effects and Genetic effects; Early effects and late effects; Non-stochastic and Stochastic effects; Relationship between cellular level damage and its role in the induction of biological effects in multicellular organisms (human beings).

Present classification of Radiation Effects- Deterministic Effects (Tissue Reactions) and Stochastic Effects; Differences between Deterministic and Stochastic Effects; Dose response curves.

Deterministic Effects: Radiation Sickness (Prodromal syndrome/ NVD syndrome); Haemopoietic Syndrome (effect on blood and blood forming organs); Blood picture changes and its consequences; Damage to bone marrow and Lethal Dose 50(60); Gastrointestinal Syndrome; CNS syndrome; oropharyngeal syndrome; Neurovascular Syndrome.

Damage to individual organs: skin; reproductive system; eye lens; lungs; Kidney; Endocrine system; Threshold doses for different deterministic effects; Kinetics of expression of damage in human beings exposed to radiation.

Late Effects of radiation; mechanism of late damage in Skin, Lungs etc.; Chronic Radiation effects; Late non-cancer effects in - Respiratory, Stroke; Cardiovascular and Digestive systems seen in A-Bomb survivors.

Factors Modifying Radiation Effects: Dose; Dose Rate (acute, protracted and chronic exposures); Radiation Type; Partial body Vs Whole body exposure; Localized exposure; Internal and External exposure; age and Gender.

Prenatal Radiation Effects- Stages of Prenatal development, Early abortions, Prenatal death, Neonatal death, Malformations; Mental retardation, Stunting and Enhanced risk of childhood cancers.

Stochastic Effects: Radiation Carcinogenesis; Mechanisms of Radiation carcinogenesis; Human data base; Atomic Bomb Survivor Data (RERF); Latent Period for leukemia and solid cancers; variation in organ sensitivity; Effect of Age and Gender; Dose response relationship; Assessment of risk of radiation carcinogenesis based on Linear No Threshold Model (LNT Model).

Genetic Effects: Lack of human data; Concept of Doubling Dose (DD) using model experimental systems (Mice). Study of Dominant and Recessive genetic disorders in mice; Dose rate effect in induction of genetic effects; Genetic risk evaluation based on background incidence of genetic disorders in human beings and DD assessed from animal data; Concepts of Adaptive Response (Hormesis), Genomic instability and Bystander effect.

Unit IV: Radiobiological Bases of Radiotherapy

Physiological compartment in tumour; Tumour Biokinetic Parameters- Cell cycle duration, potentially doubling time, volume doubling time, cell loss factor.

Model system for tumour response studies – plateau phase culture; spheroid culture; transplanted tumour system; human tumour xenografts. Radiobiological bases for fractionated radiotherapy – Survival response curve for fractionated radiotherapy, partial remission, complete remission and tumour cure.

Barendsen’s experiment with transplanted rhabdomyosarcoma cells – tumour growth delay, tumour recurrence and tumour cure.

4R’s of fractionated radiotherapy - repair of SLD; reoxygenation; redistribution; repopulation; intrinsic radiosensitivity (SF2); Role of 4Rs in Brachytherapy.

Causes of Clinical Radio resistance – hypoxia; tumour biokinetics; tumour size, repair of PLD; technical factors; Approaches to overcome tumour radioresistance.

Unit V: Bioeffect models for new modalities of radiotherapy

Light and heavy ion particle therapy; Neutron therapy; Boron Neutron Capture Therapy, radio-labeled immunotherapy; Photodynamic therapy; Thermo-radiotherapy; targeted radiotherapy; SRS/SRT; SBRT; PRRT; IMPT, IMRT, Flash Therapy.

Reference Books:

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

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MPH 502: PHYSICS OF MEDICAL IMAGING

Teaching hours: Each Unit – 12 h

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

Outcomes:

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

Unit I: Physical principle of diagnostic radiology

Interaction of low energy x-rays with human body; Effective Z values for different tissues, hypaque and $BaSO_4$; K-edge for different materials relevant to radiology; Importance of photo electric attenuation coefficients for different tissues; Variation of linear attenuation coefficients with photon energy; differential transmission and formation of the radiological image, visualization of radiographic image, development of artificial contrast using contrast media (BaSO4, Hypaque, air etc.). Limitations due to superimposition of structures and scatter radiation; projection techniques to overcome these limitations.

Calculation of transmitted photon intensity through different body tissues with and without contrast media; visualization of blood vessels and bowl with contrast media.

Components of a diagnostic X-ray unit: X-ray tube; filter; Light source (Field definer); diaphragm (field restrictor); Grid; Cassette with film and intensifying screen.

Filters: inherent filtration, added filters; beryllium filters, K edge filters-holmium, gadolinium, molybdenum, rhodium.

Role of field restrictors-shutters, holes, cones, Cylinders, positive beam limitation; Type of Grids- Stationary and moving grids; parallel grid, focused grid, crossed grid, Potter Bucky grid (moving grid); grid ratio(h/b) and reduction of scattered radiation; air gap technique.

Structure of x-ray film and image intensifying screens, rare earth screens.

Processing of x-ray film; development and fixing, drying.

Factors influencing image quality: Kilovoltage (kV); mAs and FFD; Focal Spot; Filtration; Grid; Beam Restrictors and Collimators; Film Screen Combination; Film speed; Image Amplifying Systems; projection techniques; patient dose Vs image quality; Patient dose calculation (skin exposure).

Conventional fluoroscopy procedure; Advantages of fluoroscopy in obtaining dynamic images; Modern fluoroscopy with image intensifiers; Components of an image intensifier; Intensity gain, minification gain; Image analysis-direct viewing, Spot film acquisition; Video recording; Cine fluoroscopy; CCD camera, Digital fluoroscopy.

Digital Radiography (DR) – Direct and indirect Digital Radiography systems.

Unit II: Optimization of exposure and image quality in X-ray radiography

Characteristics of Radiographic Film and Image: Density (optical density) of the film; Film speed and sensitivity; Characteristic curves (HD Curve) for different film-screen combinations; Toe, latitude and shoulder regions of HD curve; Gamma of the film; relationship between brightness contrast, exposure contrast and gamma of the film; Optimization of Exposure.

Image quality: Parameters which influence image quality: Photon fluence; unsharpness; scattered radiation; Film speed, Noise; Geometric factors; Factors influencing radiographic contrast; Factors influencing resolution; Evaluation of resolution-Point spread function (PSF); Line spread function (LSF), Edge spread function (ESF) and Modulation transfer function (MTF).

Unit III: Computed Radiography, Mammography and Fluoroscopic guided procedures

Evolution of computed tomography system, Basic principle of CT; Hounsfield Unit, Fan beam CT and Cone beam CT (CBCT). Image reconstruction techniques - Filtered Back Projection, Iterative reconstruction, Fourier transform, Spiral CT, Multislice CT (MSCT) and multidetector CT (MDCT).

Mammography: Characteristic and Bremsstrahlung based mammography procedures. Phase contrast mammography, Special features and specifications of Mammography unit; Digital Mammography, Tomosynthesis.

Fluoroscopy guided special procedures - Angiography, Cardiac catheterization; Barium meal/enema; Hysterosalpingography; biopsy; Intravenous pyelography; Arthrography; lumbar puncture, Digital subtraction angiography/Radiography systems.

Dental radiology: Panoramic and Orthopan dental radiology systems. Cone beam CT.

Unit IV: Magnetic Resonance Imaging (MRI) and Ultrasound Imaging

Magnetic Resonance image – proton density, relaxation time T1 and T2 images – Image characteristics – MRI system components – Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, Computer functions – Imaging process – Image artifacts. Transformation of MRI images to CT images (synthetic CT). MRI safety.

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

Unit V: Quality assurance of medical imaging systems

QA of X-ray radiography machines: Mechanical Check and Radiological checks- Assessment of kVp; Exposure time; mA linearity; Optical and radiation field congruence using radiopaque markers/Collimator test tool; Alignment of x-ray field and image receptor; Beam alignment test; Focal spot size using Star Pattern/Focal Spot test tool; Film screen contact check; Radiation Protection Survey of diagnostic x-ray unit.

Quality Assurance for CT scanner – mechanical test (table segmentation and laser localization), image quality related test (CT number uniformity, CT number linearity, low and high contrast resolution), CTDI and DLP. QA of mammography systems. QA of interventional radiology systems. QA of dental radiology systems.

QA of MRI scanner and ultrasonography units.

Reference Books:

1. "The Essential Physics of Medical Imaging" Jerrold T Bushberg, Second Edition 2002, LWW.
2. "Introduction to Medical Imaging Physics, Engineering and Clinical
3. Applications" N. Smith and A. Webb 2011, Cambridge University Press
4. W.J. Meredith and J.B. Massey "Fundamental Physics of Radiology" John Wright and Sons, UK, 1989

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

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MPS 503: PHYSICS OF NUCLEAR MEDICINE

Teaching hours: Each Unit – 12 h

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

Outcomes:

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

Unit I: Radionuclides and radiopharmaceuticals

Radionuclides: Out line on various uses of radionuclide in medicine - diagnostic nuclear medicine (imaging and organ functional study), therapeutic nuclear medicine (radionuclide therapy), invitro radiometric assay.

Criteria for section of radionuclide for (a) therapeutic and (b)diagnostic nuclear medicine, Role of Radiation characteristics, (role of half- life, nature of radiation and effective life,) Role of LET in radionuclide therapy, radionuclide impurity , radiochemical purity, specific activity, carrier free concept, chemical purity, radioactive concentration, carrier Decay scheme, specification, specific activity, chemical form of some of the medical radionuclide (examples I-131, P-32, Sm-153, Y-90, Lu-177, Tc-99m, Tl-208, F-18, Ga-67.

Production of radionuclide -Reactor production (neutron activation and fission) and cyclotron/ accelerator production, radiochemical processing, purification and isolation, storage and handling (time, distance, shielding).

Radiopharmaceuticals (diagnostic and therapeutic) Ready to use radiopharmaceuticals, Cold kit based radiopharmaceuticals - Theory of radioactive equilibrium-transient and secular equilibrium, Radionuclide generators, Mo-Tc generators, Ge-Ga generator, cold kit and hospital radiopharmacy, Tc chemistry (decay scheme, oxidation state etc.) Tc Cold kits formulation Tc radiopharmaceuticals formulation. PET radiopharmaceuticals. concept of biomolecular based radiopharmaceuticals (receptor, antibody based).

Unit II: Medical Cyclotron and Nuclear Imaging Devices

Types of Medical Cyclotron- unshielded and self shielded, construction and working, Radiochemistry laboratory, Planning and Shielding Calculations of Cyclotron vault, SPECT, PET. Use of cyclotron in Nuclear Medicine.

Physics of PET: Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector and scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Radiopharmaceuticals for PET imaging and clinical applications of PET.

Gamma Imagers: Rectilinear scanner and its operational principle, Anger Camera/ Scintillation camera/Gamma camera- construction and working principle. Different types of Collimators used in Anger Camera, Gamma camera. Emission Computed Tomography: Single Photon Emission Computed Tomography (SPECT).

Unit III: In vitro, In vivo Procedures

Gamma Imaging - Imaging using radio nuclides, rectilinear scanner and its operational principle. Anger Camera/scintillation camera (-System components, Detector system, Limitation of the Detector System and Electronics) – Principles, design, construction, use and maintenance. Different types of Collimators - basic principles, design, performance converging and diverging and problems, Pin hole Collimator, Focal plane Tomography, Emission Computed Tomography, Single Photon Emission Computed Tomography (SECT). Various Image Reconstruction Techniques Image Display, Recording Systems, Digital image Processing Systems, Scanning Camera.

Physics of PET and Cyclotron: Working principal of medical cyclotron, Positron emission tomography (PET) - principles of PET imaging, PET Instrumentations, PET detector and scanner design, Annihilation Coincidence Detection, Date Acquisition for PET, Data corrections and Quantitative aspect of PET, 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, and other requirements and Sources of error. Clinical applications of PET:

Unit IV: Internal Radiation Dosimetry

Compartment Models: Single and Two Compartmental Model (Equilibrium Dose Rate Equation). Two Compartmental Models with Back Transference, Two Compartmental Models without Back Transference. Classical Methods of Dose Evaluation; Beta particle Dosimetry; Gamma Ray Dosimetry, Geometrical Factor calculation. Dosimetry of Low Energy Electromagnetic Radiation. MIRD Technique for Dose calculations; Basic procedure and practical problems. Cumulative Activity. Equilibrium Dose Constant. Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem with examples. Limitation of MIRD technique.

Unit V: Category of radioisotope laboratory and QA in Nuclear Medicine

Classification and categories of Nuclear Medicine laboratories (category 1, 2, 3, 4); Required equipment and accessories, Glove box and fume hoods, Staff requirements. Delay tanks system.

QA in nuclear imaging facilities: QA of Gamma Camera; QA of SPECT; QA of PET. Flood phantom, Total quality control phantom. 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) andD.A.Rocha, Text Book of Nuclear Medicine, Vol 2 and 6, Lea and Febiger, Philadelphia, 1984.
4. Ramesh Chandra, “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.

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MPS 504: CLINICAL ASPECTS OF RADIATION THERAPY

Teaching hours: Each Unit – 12 h

Objective:

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

Outcomes:

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

Unit I: Bioeffect Models in Radiotherapy

Evolution of bioeffect models; Principle of development of models; Applications of models in radiotherapy; Strandquist's cube root law; Nominal Standard Dose (NSD), Modification of NSD into Time Dose Factor (TDF); Rontgen Equivalent Therapy (RET); Cumulative Radiation Effect (CRE); Limitations of Bioeffect models.

Development of Bioeffect model based on LQ model of cell survival.

Mechanistic bases of LQ model; Differences between the response of late responding normal tissues and tumours; Biologically Effective Dose (BED) equation for fractionated radiotherapy; Meaning of BED values for tumours and normal tissues; BED calculation for tumours and normal tissues based on α/β values; modification of BED based on fraction size; Methods to arrive at the α/β values for tumours and normal tissues.

Introduction of Time Factor into BED equation; Loss of BED due to prolongation of treatment duration; Correction of BED for tumour cell repopulation.

BED equation for LDR Brachytherapy; Effect of Dose rate on BED; BED Equation for permanent implants.

New treatment protocols based on LQ model-Multiple Fractions Daily (MFD) protocol; Accelerated Fractionation Schedule (CHART protocol); Hypo fractionated Radiotherapy. Dealing with incomplete repair and increased normal tissue BED in multiple fraction daily protocols (Optimization of inter fraction interval).

Application of LQ model for conversion of LDR protocol to HDR protocol.

Methods to deal with the gaps during fractionated radiotherapy.

Indications for improvement of radiation therapy based on LQ model.

Unit II: Radiation Generators

KV X- Ray therapy equipment: Ortho voltage therapy. Designs of Telecobalt unit - construction and working, Source capsule and source drawer, Collimation (Jaw type, multi vane type, and multi leaf) and penumbra, Penumbra Trimmers, Field size and distance measuring systems (mechanical pointers and optical point indicators). Wedge systems – Individualized and universal systems.

Medical Electron Linear Accelerator (LINAC): C-arm type and ring type LINACS, Construction and working. Collimation- Jaw type and multi leaf Collimators, Types of MLC, on board imaging and dose measuring devices (Electronic Portal Imaging Device, EPID).

Unit III: Treatment Planning System

Scope of computers in radiation treatment planning: hardware and software. Review of Algorithms used for treatment planning systems - Pencil beam Algorithms, Convolution/ Superposition Algorithms, Anisotropic Analytical Algorithms, collapsed cone algorithm, Monte Carlo based algorithms.

Plan optimization algorithms, Dose Volume Histogram-Differential and cumulative, Networking (qualitative), DICOM, DICOM-RT, PACS.

Acceptance, Commissioning and Quality Assurance of TPS as per IAEA-TRS 430.

Unit IV: Clinical aspects of Brachytherapy

Clinical approaches of brachytherapy. Intracavitary brachytherapy - ICRU89 recommendations for Intracavitary brachytherapy - Point A and Point B, bladder and rectal points and lymphatic trapezoids - types of applicators used in intracavitary brachytherapy - Fletcher Suit, ring. 3D approaches - CT and MRI compatible applicators - 3D CT/MR Based brachytherapy planning specifications.

Interstitial brachytherapy - ICRU58 recommendations for Interstitial brachytherapy- Basal points and dose optimization

Intraluminal brachytherapy - common sites, applicators and approaches - reference points for dose prescription and treatment planning

Intravascular brachytherapy - indications and approaches techniques - reference points for dose prescription and treatment planning - AAPM TG 60 recommendations

Surface Mould brachytherapy - indications and clinical considerations - reference points for dose prescription and treatment planning

Clinical indications and approaches of intra operative brachytherapy, Accelerated Partial Breast Irradiation (APB)

Clinical aspects of Ocular and prostate brachytherapy

Unit V: Dosimetry System for Brachytherapy

Source Loading and dose calculation systems – Paterson Parker, Quimby, Manchester, Paris

Point Source and Line Source Specifications as application in clinical Brachytherapy Treatment Planning Systems

Dosimetry formalisms used in brachytherapy treatment planning - Sievert Integral Method; AAPM TG43, Model based dose calculations, Monte Carlo based dose calculations.

Reference Books:

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

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MPS 505: IPR, BIOSAFETY AND BIOETHICS

Teaching hours: Each Unit – 12 h

Objectives:

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

Outcomes:

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

Unit I: Introduction to Intellectual Property

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

Unit II: Agreements and Treaties

History of GATT and TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 and 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 and 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 and 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 and Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
2. Kankanala C., Genetic Patent Law and Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

Important Links:

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

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

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

www.patentoffice.nic.in

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

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

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

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

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MPE 506: APPLICATIONS OF RADIATION AND RADIOISOTOPES IN HEALTH AND AGRICULTURE

Teaching hours: Each Unit – 12 h

Objective:

Familiarizing the students with medical and agricultural applications of radiations, radioisotopes and radiation technology.

Outcomes:

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

Unit I: Environmental Radioactivity

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

Unit II: Medical Applications

Sterilization of medical products. New drug testing - radioactive tagging; drug delivery and efficiency, Medical Imaging – X-rays, CT, MRI, SPECT and 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 andWikins, Philadelfia, 1994.
2. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
3. Bushong, Stewart C. Radiological Science for technologists – physics, biology and protection, Mosby, St. Louis, 1997.
4. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.

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PRACTICAL (HARD CORE)

MPP 507: MEDICAL PHYSICS PRACTICAL-VII

RADIATION DIAGNOSIS/MEDICINE/THERAPY (4 HR IN A WEEK)

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

Outcomes:
Students will be able to:

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

List of experiments:

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

Additional experiments may be added

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PRACTICAL (HARD CORE)

MPP 508: MEDICAL PHYSICS PRACTICAL-VIII

RADIATION DIAGNOSIS/MEDICINE/THERAPY (4 HR IN A WEEK)

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

Outcomes:
Students will be able to:

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

List of experiments:

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

Additional experiments may be added

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SEMESTER VISE SYLLABUS FOR THEORY AND PRATICAL PAPERS

IV SEMESTER

Course Code	Description of the Papers
MPH 551	Physics of Classical Radiotherapy
MPH 552	Physics of Advanced Radiotherapy
MPH 553	Radiation Protection Standards and Safety
MPS 554	Nuclear Reactors, Particle Accelerators, Industrial Applications of Radiation and Environmental Radioactivity
MPS 555	Research Methodology and Communication
MPP 556	Project

MPH 551: PHYSICS OF CLASSICAL RADIOTHERAPY

Teaching hours: Each Unit – 12 h

Objectives:

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

Outcomes:

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

UNIT I: Treatment Simulators and Beam Delivery Devices

Radiotherapy X-ray simulator - physical simulator - construction and working - collimation and delineating wires - imaging devices - clinical use of physical simulator. CT and virtual simulations - requirements of a radiotherapy CT simulator - data transmission and clinical use. Basic concept of 4D simulation.

Description of low kV therapy x-ray units - Orthovoltage therapy - Deep therapy -spectral distribution of kV x-rays and effect of filtration - thoraeus filter - output calibration procedure.

Design and working of telecobalt units - source capsule and source drawer - beam collimation

- multivane and jaw type collimators - beam penumbra - penumbra trimmers and breast cones. Reference dose rate (output in reference conditions) measurement ^{60}Co gamma ray beams using IAEA TRS 398.

Design and working of medical electron linear accelerators - electron gun - modulator and pulse generator - magnetron and klystron - accelerating wave guide - beam bending methods - x-ray target and flattening filter - filtered and unfiltered (flattening filter free, FFF) photon beams - beam collimation - asymmetric collimator - multileaf collimators - monitor chamber and monitor units - electron contamination - kV and MV imagers of the accelerator-Wedge systems in accelerators. Reference dose measurements from high energy x-rays and electron beams using IAEA TRS 398, AAPM TG 51 and other dosimetry protocols. Relative merits and demerits of kV x-rays, telecobalt gamma rays, MV x-rays and electron beams.

UNIT II: Dosimetry Parameters and Beam Modifiers

Water as universal dosimetry media and tissue equivalent phantoms. Central axis dosimetry parameters - Tissue air ratio (TAR) - Back scatter ration (BSF)/ Peak scatter factor (PSF) - Percentage depth dose (PDD) - Tissue phantom ratio (TPR) - Tissue maximum ratio (TMR) - Collimator, phantom and total scatter factors. Relation between TAR and PDD and its applications - Relation between TMR and PDD and its applications. Mayneord F-factor for extended SSD calculations, Equivalent squares and Sterling approximation, Scatter Air Ratio (SAR), Scatter Maximum Ration (SMR), Off Axis Ratio (OAR) and Field factor. Build-up region and surface dose. Radiation filed analyzer (RFA) and its use in beam dosimetry. Description and measurement of isodose curves/charts. Dosimetry data resources.

Beam modifying and shaping devices, Wedge filters - design of wedge filters - individualized and universal wedges - wedge transmission factor - motorized and dynamic wedges. Shielding blocks and custom blocking, Tissue compensation - Bolus - Tissue compensators - design of tissue compensators - compensator transmission factor.

UNIT III: Photon Beam Techniques and Patient Dosimetry

Classical/conventional techniques of radiotherapy. Target volume definition and dose prescription criteria - ICRU 50 and ICRU 62 - SSD and SAD set ups - open and wedge fields - Single and multiple field treatments - Parallel opposed beams - Oblique combination of beams - Box field technique. Treatment planning in teletherapy - two and three dimensional localization techniques - contouring - simulation of treatment techniques - field arrangements - corrections for surface irregularity and tissue inhomogeneity - contour shapes and beam obliquity - integral dose. Arc/ rotation therapy and Clarkson technique for irregular fields - mantle and inverted Y fields. Conventional and conformal radiotherapy. Treatment time and Monitor unit calculations. Portal and in-vivo/on-line dosimetry. Use of Electronic portal imaging device in set up and patient dose verification.

UNIT IV: Electron Beam Therapy and QA of Beam Therapy Equipment

Clinical electron beams - energy specification - electron energy selection for patient treatment - depth dose characteristics (D_s, D_x, R_{100}, R_{90}, R_{50}, R_p etc.) - beam flatness and symmetry - penumbra - isodose plots - monitor unit calculations (regular and irregular shapes) - output factor formalisms - effect of air gap and obliquity on beam dosimetry - effective SSD - corrections for contour irregularity and tissue inhomogeneity. Treatment planning in electron beam therapy.

Quality assurance of beam therapy equipment - precision and accuracy in clinical dosimetry - quality assurance protocols for telecobalt, medical electron linear accelerator and radiotherapy simulators - IEC requirements - acceptance, commissioning and quality control of telecobalt, medical electron linear accelerator and radiotherapy simulator.

UNIT V: Physical aspects of Brachytherapy

Definition of Brachytherapy and details of brachytherapy sources - Ideal requirement for brachytherapy sources, Description of radium and radium substitutes - Cs-137, Co-60, Ir-192, I-125, Pd-103 and other commonly used brachytherapy sources. Pre-loading and after-loading brachytherapy techniques. Manual and remote after loading techniques. After loading techniques - Advantages and disadvantages of manual and remote after loading techniques. AAPM and IEC requirements for remote after loading brachytherapy equipment.

Acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment. ISO requirements and QA of brachytherapy sources. Integrated brachytherapy unit.

Brachytherapy treatment planning, GEC ESTRO recommendations, Forward and inverse planning – DICOM image import / export from OT, Record and verification. Physical aspects of Intravascular brachytherapy - classification – sources. Electronic brachytherapy (Axxent, Mammosite, etc.).

Reference Books:

1. H.E. Johns and Cunningham, The Physics of radiology
2. Faiz M. Khan, Roger A. Potish, treatment Planning in radiation Oncology
3. Walter and Miller's Textbook of Radiotherapy by C.K.Bomford, I.H.kunkler

4. F.A.Attix "Radiation Dosimetry" Vol IIII, 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.

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MPH 552: PHYSICS OF ADVANCED RADIOTHERAPY

Teaching hours: Each Unit – 12 h

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

Outcomes:

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

Unit I: 3D conformal radiotherapy and special techniques of radiotherapy

Advantage of 3DCRT over classical/conventional techniques, Indications for 3DCRT - patient data acquisition - imaging - CT simulation imaging - MRI imaging – PET imaging - image registration (Rigid and deformal) - image segmentation - contouring - beam selection - dose calculation - dose calculation algorithms- dose distribution and plan optimization - plan evaluation - dose volume histogram (DVH) - treatment chart and treatment setups.

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

UNIT II: Intensity modulated radiotherapy and Image guided radiotherapy

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.

Concept of Intensity Modulated Arc Therapy (IMAT/VMAT), Image Guided Radiotherapy

(IGRT) - Imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures - special phantom, 4DCT.

Principles of Serial and Helical irradiation – equipment design and working principle - commissioning - imaging - planning and dosimetry - dose delivery - plan adaptation - QA protocol and procedures.

Fundamentals of Ring gantry accelerators for radiotherapy.

UNIT III: Stereotactic Radiosurgery and Stereotactic Radiotherapy

Stereotactic radiosurgery / stereotactic radiotherapy (SRS/SRT) - cone and MLC based X-Knife systems- accessories of X-knife – Multi source radiosurgery device (Gamma Knife) - various models and accessories of Gamma Knife systems - immobilization devices for SRS/SRT – Frame and frameless radiosurgery techniques - dosimetry and planning procedures - Evaluation of SRS/SRT treatment plans - QA protocols and procedures for X-knife and Gamma Knife units - Patient specific QA.

Principles of stereotactic body radiotherapy (SBRT) - indications for SBRT. Simulation Imaging - Data acquisition for mobile tumors - patient-specific tumor-motion determination - respiratory motion management - Imaging artefacts. Treatment planning - Dose heterogeneity - gradient and fall-off - beam selection and beam geometry - calculation grid size - bio-effect based treatment planning. Immobilization - image guided localization - tumour tracking and gating techniques for motion management - dose delivery data reporting. Dosimetry techniques of small and narrow fields - calculation under heterogeneous conditions. Requirements for clinical commissioning of SBRT - acceptance, commissioning and quality assurance.

Frameless radiosurgery systems – Robotic radiosurgery device (Cyber Knife) - Systems descriptions - Indications for cyber knife treatments - systems for beam collimation and beam shaping - imaging - patient monitoring and treatment - dose calculation techniques - clinical commissioning and quality assurance.

UNIT IV: Proton Therapy

Proton therapy accelerator - acceleration and transport of proton beam - treatment nozzle - characteristics of therapy proton beam - Spread Out Bragg Peak (SOBP) - beam quality - pencil beam - spot scanning – Intensity Modulated Proton Therapy (IMPT) - dosimetry - phantoms and dosimeters - ionization chambers, calorimeters and film dosimetry methods - relative dosimetry methods - dosimetry using TLD/OSLD, semiconductor diodes and radiochromic films. Treatment planning system - dose calculation algorithms - dose optimization approaches - intensity modulated proton therapy - imaging and motion management. Quality assurance, commissioning and reporting of proton therapy treatments.

UNIT V: Neutron and Heavy Ion Therapy

Principles of neutron capture therapy (NCT) - Boron and Gallium capture therapy - NCT systems and beam shaping - indications for NCT - treatment planning and dose computation - clinical commissioning and QA of NCT systems.

Heavy ions for radiotherapy - heavy ion accelerator - design and working principle -energy specification and beam quality - indications for heavy ion therapy – imaging, treatment planning and dosimetry - plan optimization and dose delivery approaches. Beam characteristics, commissioning and quality assurance.

Reference Books:

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

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MPH 553: RADIATION PROTECTION, STANDARDS AND SAFETY

Teaching hours: Each Unit – 12 h

Objective:

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

Outcome:

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

Unit I: Radiation Protection Standards

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – ICRP recommendations – Basics 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 Radiation Hazard Evaluation

Effects of distance, time and shielding. Inverse square law. Linear Attenuation Coefficient, Mass Attenuation Coefficient. Narrow Beam/good geometry, Broad beam geometry, HVT, TVT, and the relation between TVT and HVT.

Radiation Hazard Evaluation by Calculation and measurement - Calculation of specific gamma constant - RHM, RMM. Shielding for Alpha, Beta and Neutron sources. Area Monitoring, air monitoring, personal monitoring.

Internal Hazard Evaluation: Inhalation, ingestion, and Absorption, Physical Decay, Biological Decay. Internal hazard evaluation by calculation and measurement. Contamination of air and work surfaces, person and samples. Radiotoxicity of different radionuclides. Classifications of laboratories – General requirements of class A, class B and class C laboratories – Basic Principles for control of contamination, Methods of decontamination. Whole body counting and Bioassay.

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 III: Vault design and shielding calculations for medical radiation facilities

General considerations for medical radiation facilities - site selection, area requirements, shielding materials.

Parameters used for shielding calculations -Use factor, workload, Occupancy Factor, TVT, HVT, radiation dose permissible limits, designing of radiation installation and shielding calculations: ceiling, primary barrier, secondary barrier, maze barrier and its importance, thickness and width of the primary barrier, secondary barrier thickness, barrier against scattered and leakage radiations, radiation at the door level. Dose due to primary, leakage, and scattered radiations.

Layout planning and shielding calculations for telecobalt facility. Layout planning and shielding calculations for LINAC facility - shielding against neutrons in high energy electron LINAC.

Layout planning and shielding calculations for HDR remote after loading brachytherapy facility – workload calculations, use and occupancy factors. Layout planning and shielding calculations for specialized radiotherapy facilities (gamma knife, cyber knife, tomotherapy).

Workload of x-ray machine, shielding calculation for diagnostic X-ray facilities (X-ray radiography, CT scanner, mammography and dental radiology).
Layout planning and shielding of nuclear medicine facilities and radioisotopes laboratories.

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 hospital/medical, industrial, agricultural and research establishments.

Unit V: Transport, Legislation and Radiation Emergencies in workplaces

Transport of Radionuclides: Transportation of radioactive substances – Historical background – General packing requirements – Transport documents (TREM and TRAM cards) – Labeling and marking of packages. A1 and A2 values of radionuclides, Transport index – Types (A,B,C) and categories (I,II,III) of packages. Test conditions for type A, B and C packages. Regulations applicable for different modes of transport – Transport by post – Transport emergencies – Special requirements for the transport of large radioactive sources and fissile materials – Exemptions from regulations – Shipment approval – Shipment under exclusive use – Transport under the special arrangement – Responsibilities of Consignor/Consignee and carrier.

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 (security plan for radioactive sources/radiation facilities). National legislation – Regulatory framework – Atomic Energy Act 1962– Atomic Energy (Radiation Protection) Rules 2004 – 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. Dominowski R L: Research Methods (Prentice Hall of India, N J 1980)
2. Henry Stark and John Woods: Probability and random processes with applications to Signal
1. Processing (3rd Edition, Pearson Education Asia, 2002).
2. Herman Cember. Introduction to Health Physics
3. Atomic Energy Act 1962
4. AERB Radiation Protection Rules 2004
5. ICRP 1990 Recommendation
6. ICRP 2007 Recommendation
7. IAEA Basic safety standards 115, 1997
8. Shapiro T. radiation Protection
9. Mckenzie. Radiation Protection in radiotherapy
10. Mawson C.A. management of Radioactive wastes.
11. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
12. S.P.Yaremonenko, "Radiobiology of Humans and Animals", MIR Publishers, Moscow, 1988.
13. R.F. Mold "Radiation Protection in Hospitals" Adam Hilger Ltd. Bristol, 1985.
14. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey and Sons, Inc. New York, 1981.
15. NCRP, ICRP, ICRU, IAEA, AERB Publications.

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MPS 554: NUCLEAR REACTORS, PARTICLE ACCELERATORS, INDUSTRIAL APPLICATIONS OF RADIATION AND ENVIRONMENTAL RADIOACTIVITY

Teaching hours: Each Unit – 12 h

Objectives:

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

Outcomes:

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

Unit I: Nuclear Reactors

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

Unit II: Particle Accelerators

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

Unit III: Applications of radiation and radioisotopes in industry

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: Applications of radiation and radioisotopes in agriculture

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.

Unit V: Environmental Radioactivity – Natural and anthropogenic

Environmental radioactivity – sources of natural radioactivity, terrestrial and atmospheric radioactivity. Radon and Thoron. Dose contributions from different sources. High background radiation areas. Cosmogenic radionuclides. Technologically enhanced natural radioactivity.

Environmental Radioactivity – anthropogenic: 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.

Methods for quantification natural and anthropogenic radioactivity in the environment.

Reference Books:

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

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MPS 555: RESEARCH METHODOLOGY AND COMMUNICATION

Teaching hours: Each Unit – 12 h

Objectives:

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

Outcomes:

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

Unit I. Introduction to Research: General.

Definition, Research objectives, Research approaches, Significance of research and importance of knowing how research is done; Criteria of good research; Types of Research: Pure, Applied and Need based research, Variation of Research: Diagnostic, Descriptive, and Exploratory, Research Ethics – Animal ethics; Human ethics; Bio-safety in research: microorganisms studies Scientific methods, components 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; 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 and Research Design.

Types of Literature search – use of library, books and journals – internet surfing, 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; 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 Methodologies and Interpretation.

Data collection: Qualitative and Quantitative data, exploratory data analysis; Meaning, Relevance, limitations and cautions. Data Collection methods: Interview; Observation; Questionnaire; Scope of survey based research, Types of surveys – specific, periodic and 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 and external), Reliability of the tools. Meaning of Interpretations; Techniques of Interpretation, Precautions in Interpretations.

Unit IV Problem Solving and Creativity.

Learning strategy of problem solving; Bacon's Theorem and Moore's Law; Creativity Level and styles of thinking; common-sense and scientific thinking; examples. Problem solving strategies reformulation or rephrasing. Techniques of representation, Logical thinking, division into sub-problems, verbalization. awareness of scale; importance of graphical representation; closed minds; multiple approaches to a problem analytical vs analogical reasoning, puzzle solving; example; prepared mind, Creative problem solving using Triz Prescriptions; 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 and Scientific Writing.

Definition and kinds of scientific documents – research paper, review paper, bookreviews, 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; 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 and 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 AgeInternational;1990 (e-published in 2009).
3. Research Methodology Methods and Statistical Techniques ;Santosh Gupta; New Delhi:Deepand Deep Publications ; 2000.
4. Research Methodology ; Indrayan
5. E.M. Phillips and D.S. Pugh," How to get a Ph.D-a handbook for Ph.D students and their supervisors", Viva books Pvt. Ltd for all scholars irrespective of their disciplines.
6. Hand book of Science Communication, compiled by Antony Wilson. Jane Gregory,
7. Steve Miller, ShirelyEarl.Overseas Press India Pvt. Ltd, New Delhi. First edition 2005
8. G.L Squires," Practical physics", Cambridge University Press, for all scholars except those from Humanities and management Sciences.
9. Peter b Medewar," Advice to a Young Scientist", Pan Books. LONDON. 1979.
10. D C Montgomery, Design and Analysis of Experiments

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PROJECT WORK

MPP 556: PROJECT WORK – 10 HRS/WEEK

Students to undertake project work and submission of the project dissertation on a topic relevenat to the medical physics or application of radiation and radioisotopes.

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