THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY
CHENNAI-600 032

REGULATION AND SYLLABUS
M.Sc. (MEDICAL PHYSICS)
2008-2009

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
CHENNAI – 600 032
M.Sc. MEDICAL PHYSICS

THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY, CHENNAI – 600 032.

REGULATIONS OF THE UNIVERSITY

In exercise of the powers conferred by Section 44 of the Tamil Nadu Dr. M.G.R. Medical University, Chennai, Act, 1987 (Tamil Nadu Act 37 of 1987), the Standing Academic Board of the Tamil Nadu Dr. M.G.R. Medical University, Chennai hereby makes the following regulations:-

1. SHORT TITLE AND COMMENCEMENT:-

These regulations shall be called "THE REGULATIONS FOR **M.Sc**., (**MEDICAL PHYSICS**) POST GRADUATE DEGREE COURSE OF THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY, CHENNAI". The course shall be of "Three Years" duration including one year compulsory internship. The course is designed to enable the students to acquire adequate knowledge and skill in Medical Physics and allied Sciences. They shall come into force from the academic year 2008-2009 session onwards. The regulations framed are subject to modification from time to time by the Standing Academic Board or Council.

2. OBJECTIVES:-

Medical physics is a discipline concerned with

(a) Application of physical concepts and methods to the understanding of human body in health and disease

(b) Introduction of new and more precise techniques into the investigation and treatment of the individual patient, and

(c) Ensuring the availability and use of resources of physics in day –to –day medical practice.

(d) At the end of the course the student must have an in depth knowledge in the field of Medical Physics.

(e) Have an understanding about the radiation applications in diagnosis and treatment and its impact on health care and health care delivery.

3. MINIMUM QUALIFICATION FOR ADMISSION :-

The candidates for admission to the first year of the Post Graduate Degree Programme of Medical Physics shall be required to have passed B.Sc.(Physics /Applied Physics) with Mathematics as one of the ancillary subject.

4. AGE LIMIT FOR ADMISSION:

A candidate should have completed the age of 20 years at the time of admission or would complete the age on or before 31st December on the year of admission to the first year M.Sc.(Medical Physics) course.

5. PHYSICAL FITNESS CERTIFICATE:-

Every candidate before admission to the course shall submit to the Head / Director of the Institution a certificate of medical fitness from an authorized medical officer that the candidate is physically fit and mentally sound to undergo the academic course and does not suffer from any disability or contagious disease.

6. ELIGIBILITY CERTIFICATE:

Candidates who have passed any qualifying examination, as specified in Regulation No.2 above from any other Universities other than the Tamil Nadu Dr. M.G.R. Medical University before seeking admission to the affiliated institutions shall obtain an Eligibility Certificate from the University by remitting the prescribed fees along with the application form which shall be downloaded from the University website (www.tnmmu.ac.in).

7. CUT-OFF DATES FOR ADMISSION TO THE EXAMINATION:-

a) The Candidates admitted from 1st July to 30th September of the Academic Year will be registered to take up their first year M.Sc.(Medical Physics) examination after fulfillment of the regulations in March of the Academic Year.
b) All kinds of admission shall be completed on or before 30th September and there shall not be any admission after the above date even if seats are vacant.

8. REGISTRATION:

A candidate admitted to the M.Sc., (Medical Physics) degree course shall register his/ her name by submitting the prescribed application form for registration duly filled in by remitting the prescribed fee to the Tamil Nadu Dr. M.G.R. Medical University within 60 days from the cut off date prescribed for M.Sc., (Medical Physics) degree course.

9. DURATION OF THE COURSE:

The duration of certified study for the M.Sc., (Medical Physics) shall extend over period of three academic years including one year compulsory Internship.

10. COMMENCEMENT OF THE COURSE:-

The course will commence from 10th October of the Academic Year.

11. COMMENCEMENT OF EXAMINATION:

There shall be two University examinations in an academic year. The Annual Examinations will commence from September 15th and the supplementary Examinations will commence from April 15th of every academic year.

If the date of commencement of the examination falls on Saturdays, Sundays or declared Public Holidays, the examination shall begin on the next working day.

12. CARRY OVER OF FAILED SUBJECTS :- The Candidate is permitted to go to the second year but he/she will not be permitted to undergo internship in the third year unless he / she clears all the first & second year subjects.

13. CURRICULUM:

The Curriculum and the Syllabus for the course shall be as prescribed by the Standing Academic Board from time to time.

14. MEDIUM OF INSTRUCTION:

English shall be the medium of instruction for all the subjects of study and examination of the M.Sc. (Medical Physics) Degree course.

1**5. WORKING DAYS IN AN ACADEMIC YEAR** : -

Each academic year shall consist of not less than 240 working days.

16. ATTENDANCE REQUIREMENT FOR ADMISSION TO EXAMINATION:-

a) In the first year the candidate should have 90% of attendance in Theory and practical before appearing for the exam.

b) No candidate shall be permitted to any one of the parts of M.Sc., (Medical Physics) unless he / she has attended the programme for the prescribed period in the institution and produces the necessary certificate of study, attendance and progress from the Head of the institution.

c) A candidate lacking in the prescribed attendance and progress in any one subject in theory or practical in the first appearance shall not be permitted to appear for the entire examination.

d) Attendance earned by the students should be displayed on the Notice Board of the college at the end of every 3 months and copy of the same should be sent to the University and parents of the students concerned.

17. CONDONATION OF LACK OF ATTENDANCE:

There shall be no condonation of lack of attendance in Post Graduate degree programme.

18. INTERNAL ASSESSMENT MARKS:-

The Internal Assessment should consist of the following points for Evaluation:-

i) Theory
ii) Seminar / assignment / conference
iii) Journal club discussions
iv) Practical / Clinical
v) Viva voce

The Internal Assessment of the candidate has to be assessed on the above points and a report has to be submitted by the institution as detailed below:-

The aggregate of Final Internal Assessment Marks should be submitted 2 months before the commencement of the exam as per scheme of examination shall be taken by the University as Internal Assessment Marks and minimum of 50% marks is mandatory for permitting the candidates to sit for the University examinations.

19. DISSERTATION & EVALUATION:-

The topic of the dissertation should be submitted at the end of the first year of the course. The candidate should also inform the name of the guide for the dissertation to the University while submitting the dissertations topic.

If there are changes in the dissertation topic, the same has to be informed six months prior to the final year examination.

The dissertation should be submitted duly signed by the Professor of Medical Physics and the same has to be forwarded to the Controller of Examination through the Head of the Institution two months prior to the Examination.

No marks will be allowed for dissertation. The Board of Examiners should mark the dissertation either “approved” or “not approved.”

If the dissertation is not approved by the majority of the examiners, the results shall be withheld till the resubmitted dissertation is approved.

If the candidate fails in the Written / Practical Examination, but his / her dissertation is approved, the approval of the dissertation shall be carried over to the subsequent examination.

21. MAINTENANCE OF LOG BOOK:-

a) Every Post Graduate candidate shall maintain a record of skills (Log Book) he / she has acquired during the two years training period, certified by the various Heads of Department, where he / she undergoes training.

b) The candidate is also required to participate in the teaching and training programme for the under-graduate students.

c) In addition, the Head of the Department shall involve their Post-graduate students in Seminars, Journal Group Discussions and participation in Conferences.

d) The Head of the Department shall scrutinize the Log Book once in every three months.

22. AWARD OF DEGREE :-

The degree shall be awarded by the University only after the successful completion of the course and one year compulsory internship.

23. AWARD OF MEDALS / PRIZES:-

The University shall award at its Convocation, medals and prizes to outstanding candidates as and when instituted by the Donors as per the schedule prescribed for the award.

24. QUALIFYING MARKS FOR PASS :-

50% of marks in University theory examination ;
50% of marks in University Practical examination and
50% of aggregate marks in Theory, Internal Assessment, Practical and Oral Examination.

25. RETOTALLING OF ANSWER PAPERS:-

Re-totalling is allowed in the failed subjects.

26. NUMBER OF APPEARANCE / COMPLETION OF THE COURSE OF STUDY:

A candidate registered for three year M.Sc.,(Medical Physics) Course including one year Compulsory Residency Training must qualify in the examinations within four years from the date of his / her admission excluding the period of Compulsory Internship.

27. RE-ADMISSION AFTER BREAK OF STUDY :

As per the procedure laid down in a common regulation for all the courses of the Tamil Nadu Dr. M.G.R. Medical University.

28. MIGRATION / TRANSFER OF CANDIDATES :-

Request for Migration / Transfer of candidates during the course of study from one recognized Institution to another recognized Institution of this University or from other University shall not be granted under any circumstances.

29. VACATION :-

The Heads of Institutions shall declare 6 (six) weeks vacation in an academic year to the students. The period of vacation can be decided by the Head of the Institution.

30. AUTHORITY TO ISSUE TRANSCRIPT :-

The Controller of Examinations shall be the authority for issuing transcript of marks after remitting the prescribed fee.

31. SUBMISSION OF PRACTICAL RECORD BOOKS :-

At the time of Practical Examination, each candidate shall submit to the Examiners his / her Practical Record Books duly certified by the Head of the Department as a bonafide record of the work done by the candidate.

The concerned Head of the Department shall evaluate the Practical Record (Internal Assessment) and the Practical Record shall be presented to the Examiner.

32. COMPULSORY INTERNSHIP :-

The candidate shall not be allowed to undergo compulsory Internship unless he / she clears all the second year subjects and dissertation approval.

During the Compulsory Internship, students are expected to note down their observations in the log book. On the day of reporting after completion of posting of training, the students should submit a field training report to the institution.

The report, presentation and the log book will be evaluated periodically and taken under performance assessment.

33. SUBJECTS OF STUDY :

PROPOSED CURRICULUM FOR M.Sc. (Medical Physics)

FIRST YEAR

Paper I Anatomy and Physiology
Paper II Mathematical Physics
Paper III Electronics & Instrumentation
Paper IV Computational Methods in Physics
Paper V Basic Radiation Physics
Paper VI Radiation Dosimetry
Paper VII Physics of Diagnostic Radiology
Paper VIII Physics of Radiation Therapy
Practical

SECOND YEAR

Paper I Physics of Medicine & Biology
Paper II Bio-Medical Instrumentation
Paper III Radiation Biology
Paper IV Physics of Nuclear Medicine
Paper V Advanced Medical Imaging Physics
Paper VI Radiation Safety & Regulations
Practical
Project & Vivo-voce

34. QUESTION PAPER PATTERN :

Theory :

2 Essays	20 x 2	40
10 Short Notes	10 x 6	60
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		100 Marks

Practical :	**First Year**	**Second Year**
Practical exam	50	50
Internal mark	50	50
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	100 Marks	100 Marks
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Project & Vivo-voce 100 marks

SYLLABUS FOR M.Sc. (MEDICAL PHYSICS)

FIRST YEAR SUBJECTS

1. Anatomy & Physiology
2. Mathematical Physics
3. Electronics & Instrumentation
4. Computational Methods in Physics
5. Basic Radiation Physics
6. Radiation Dosimetry
7. Physics of Diagnostic radiology
8. Physics of Radiation Therapy Practicals
   Practical

SECOND YEAR SUBJECTS

1. Physics of Medicine and Biology
2 Bio-Medical Instrumentation
3. Radiation biology
4. Physics of Nuclear Medicine
5. Advanced Medical Imaging physics
6. Radiation safety and Regulations
   Practicals
7. Project & Vivo-voce

THIRD YEAR

1. Internship:
   a. One year internship at a leading hospitals / institutions having radiation facilities including imaging, Radiation therapy and Nuclear Medicine
   b. One/two weeks Radiation safety training at the Radiation physics and Advisory Division, Bhabha Atomic Research Centre, Mumbai for Radiological safety officer (RSO) certification, to fulfill the norms of the Atomic Energy Regulatory Board.

FIRST YEAR

1. ANATOMY & PHYSIOLOGY

1. Definitions and surface anatomy:

Applications, History – Cells, structure and functions, sex cells, early development – The tissues – the systems – skin, cartilage and bone – Bacteria – Inflammation – Injection – ulceration – neoplasma, bones – the skeleton – joints – The skeletal system – the skull – vertebral column, thorax Upper Extremity, Lower Extremity etc. – the muscular system -the thoracic cage – the mediasternum, the diaphragm the abdominal cavity and abdominal regions – anatomy of the heart.

Superior Extremities, Inferior Extremities, Ossification centers, Bone of Upper Limb, Radius and ulna, surface marker of Thorax, Abdomen, Head and Neck.

2. Digestive system & Circulatory system:

Functions of mouth, tongue, teeth, esophagus, Salivary Glands, stomach, small intestine, Duodenum, large intestine, Jejunum, Ileum Pancreas, Liver, Biliary System.– digestion and assimilation of carbohydrates – Fats and proteins – Gastric juice – Pancreatic juice – Function of liver and spleen.

Blood and circulatory system, Blood and its composition, RBC and WBC – blood grouping – coagulation of blood, Plasma, artery, vein, capillaries and heart structure and functions – Physiological properties of heart muscle, cardiac dynamics – EEG – blood pressure and its regulation.

3. Respiratory & Endocrine system:

Physical laws of respiration – Nose, Pharynx, Bronchi - Trachea – Lungs and its functions – oxygen transport –Physiology of Respiration – Lung Volume and capacity, control, gas exchange.

Pituitary glands and its functions – functions of adrenal, thyroid, Pancreas etc. secretion – chemistry – physiological actions, effects on removal effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action - Insulin.

4**. Reproduction system & Nervous system:**

(a). Male: Reproductive System – Testis, Functions, ducts, Male infertility.

(b) Female Reproductive System: Ovaries, Fallopian Tube, Vagina, Breast, reproductive Cycle, Menstruation, Maturation, Fertilization.

Brain and spinal cord – its functions - central nervous system and Autonomic Nervous system functions – Physiology of special senses of hearing, taste vision

5.Excretory system & Sensory system:

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

6.Radiographic anatomy and diseases:-

Anatomy and physiology as applied to radiodiagnosis and radiotherapy – Xray anatomy –CT/MRI anatomy-surface anatomy applied to RD and RT – introduction to the nature of diseases and trauma-inflammation and infection.

BOOKS FOR STUDY AND REFERENCE:

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

2. MATHEMATICAL PHYSICS

Unit 1. Vector Analysis

The scalar and vector fields – Gradient, Divergence, curl and Laplacian – Orthogonal and curvilinear co-ordinates – Rectangular, cylindrical and spherical co-ordinates. Vector integration – Line integrals, surface integrals and volume integrals – Gauss Divergence theorem – Stokes theorem and Green's theorem .

Unit 2. Tensor Analysis

Definition – Transformation of co-ordinates – Summation convention – Contravariant, covariant and mixed tensors – Rank of a tensor – Symmetric and antisymmetric tensors – Associated tensors – Raising and lowering of suffixes – Metric tensor – Riemannian spaces – Christoffel's three index symbols – Law of transformation for Christoffel's symbols .

Unit 3. Matrix and Vector Space

Matrix : Characteristic equation of a matrix – Eigenvalues and eigenvectors - Cayley – Hamilton theorem - Inverse of a square matrix - Reduction of a matrix to diagonal form

Vector Space : Linear Vector Space –Basis – Change of basis – Inner product – Gram-Schmidt's orthogonalization process – Schwarz inequality.

Unit 4. Differential Equations

Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Frobenius method – Variation of parameters – Sturm – Liouville differential equation – Linear partial differential equations – Separation of variables – Examples : the wave equation, Laplace equation and diffusion equation

Unit 5. Special Functions

Orthogonal functions – Bessel, Legendre, Hermite and Laguerre differential equations – Their series solutions – Recurrsion relations – Gamma and Beta functions – Dirac delta function

Books for Study and Reference

Relevant chapters in

1. Vector Analysis, Schaum's outline series (1974) M. R. Spiegel, McGraw – Hill, New York.
2. Applied Mathematics for Engineers and Physicists (1970) I. A. Pipes and L. R. Harvill, McGraw Hill, London.
3. Mathematical Physics (1992), P.K. Chattopadhyay Wiley Eastern, New Delhi
4. Advanced Engineering Mathematics (1983), E. Kveyszig, Wiley Eastern, New Delhi.
5. Differential Equations, (1973), Schaum's outline series R. Bronson, McGraw Hill, New York
6. Mathematical Physics, (2003), H. K. Dass S. Chand and Co, New Delhi.
7. Matrices and Tensors in Physics, (1995) A. W. Joshi, Wiley Eastern, New Delhi

3. ELECTRONICS & INSTRUMENTATION

1. Semiconductor Devices

Semiconductor diodes – Characteristics – Zener diode – Schottky – Tunnel – Junction transistors – UJT-SCR – JFET – MOSFET – Opto electronic devices – Photodiode – Solar cell – LED, LCD and phototransistor – Principle of integrated circuits – Fabrication processes: Diodes, transistors, resistors, capacitors – Linear and digital ICs- LSI, MSI

2. Applications of Semiconductor Devices

Amplifiers: Junction (Bipolar) transistor amplifiers in three configurations – Types of coupling : DC, RC and transformer couplings – FET and MOSFET amplifiers – DC amplifier – Power amplifiers : Class B–Push-pull amplifier – Two-port net work analysis using 'h' parameters – CE, CC, CB amplifiers – Measurement of 'h' parameters
Oscillators: General theory – Feed back requirements – Phase shift oscillator – Crystal controlled oscillator – Negative resistance oscillator – Relaxation oscillators.

3. Operational Amplifier and its Applications

Linear ICs – OPAMPS – Characteristics – Basic applications – Inverting and noninverting amplifiers – Adder – Subtractor – Integrator – Differentiator – Phase shifter – Comparator – Butterworth active filters – Waveform generator – Multivibrators: Bistable, Monostable – Schmitt tigger – Solutions of differential equations – Analog computation

4. Digital Principles, Analog and Optical Communication

Flip-flops - R-S, J-K, Master-Slave flip-flops – Shift registers – Counters – A/D, D/A Converters – Memory devices – Structure and operations of RAM – ROM – PROM, EPROM – Microprocessor Architecture (Qualitative ideas only)

Modulation - Demodulation – Principles of Amplitude, Frequency and phase Modulations – Simple circuits for amplitude and frequency modulation and demodulation – Digital modulation: Pulse modulation - PAM, PPM, PDM, PCM modulators.
Optical communication: Fundamentals – Optical fibres – Optical sources: Lasers – Characteristics.

5. Linear and Nonlinear circuits

V-I characteristic of two terminal linear and nonlinear elements – resistors, capacitors, inductors – example – PWL circuit elements – Chua's diode – nonautonomous and autonomous nonlinear circuits – Nonlinear oscillators – Dynamics of Murali-Lakshmanan-Chua (MLC) and Chua's nonlinear circuits.

Books for Study and Reference

1. J. Millman & C.C. Halkias, Electronic Devices and Circuits, McGraw Hill Singapore (1972)
2. A.P.Malvino, Electronic Principles, TMH Edition, New Delhi (1995)
3. A.P.Malvino & D.P.Leech, Digital Principles and Applications, TMH Edition (1994)
4. Robert Bolyestad and Louis Nashelsky, Electronic Devices and Circuit Theory, (Prentice-Hall of India, New Delhi 1996)
5. George Kennedy, Electronic Communication Systems, Tata McGraw Hill, New Delhi (1995)
6. L.O. Chua, C.A. Desoer & E.S.Kuh Linear and Nonlinear circuits (McGraw Hill Singapore, 1987)
7. M. Lakshmanan and K. Murali, Chaos in Nonlinear Oscillators. Controlling and Synchronization (World Scientific, Singapore, 1996)

4.COMPUTATIONAL METHODS IN PHYSICS

1. Programming in Fortran 90/95

Elements of Fortran 90/95 - Constants and Variables – Arithmetic Expressions - I/O statements - Logical expression - Conditional and control statements - Arrays - Function and Subroutines – Format statements - Advanced Features:- Procedures, Modules, Recursive functions and Generic Procedures.

2. Curve fitting and solutions of linear and nonlinear equations

Curve fitting : Method of least squares - Normal equations – Straight line fit - Exponential and power-law fits. Simultaneous linear equations : Gauss elimination method - Jordan's modification. Roots of nonlinear equations: Newton-Raphson method - Iterative rule -Termination criteria - Pitfalls.

3. Interpolation

Newton interpolation polynomial : Linear interpolation - Higher-order polynomials - First-order divided differences - Gregory-Newton interpolation polynomials -Lagrange interpolation - Truncation error.

4. Numerical integration and differentiation

Newton-Cotes quadrature formula - Trapezoidal, Simpson's 1/3 and 3/8 rules - Errors in the formulas – Composite Trapezoidal and Simpson's rules - Errors in the formulas. Differentiation : First-order derivative:- Two- and four-point formulas - Second-order derivative:- Three- and five-point formulas.

5. Numerical solution to ordinary differential equations

First-order equations : Euler and improved Euler methods - Formulas - Local and global truncation errors - N-th order Runge-Kutta methods - Fourth-order Runge-Kutta method – Geometric description of the formula - Errors versus step size - Second-order equations - Euler methods and Fourth-order Runge-Kutta method.

Books for Study and Reference

Relevant chapters in

1.V. Rajaraman, Computer Programming in FORTRAN 90 and 95 (Prentice-Hall of India, New Delhi, 1997).
2.S. J. Chapman, Introduction to FORTRAN 90/95 (McGraw-Hill Book Co., Singapore, 1998).
3.M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation (New Age International, New Delhi, 1993).

4.J. H. Mathews, Numerical Methods for Mathematics, Science and Engineering (Prentice-Hall of India, New Delhi, 1998).

5. BASIC RADIATION PHYSICS

1. Basic Nuclear Properties

Nuclear size, shape, mass – Charge distribution – Spin and parity – Binding energy – Semi empirical mass formula – Nuclear stability – Mass parabola

Nuclear Forces

Nature of nuclear forces – Ground state of deuteron – Magnetic dipole moment of deuteron – Proton-neutron scattering at low energies – Scattering length, phase shift – Properties of nuclear forces – Spin dependence – Charge symmetry – Charge independence – Repulsion at short distances – Exchange forces – Meson theory

2. Radioactive Decays

Alpha emission – Geiger – Nuttal law – Gamow theory – Neutrino hypothesis – Fermi theory of beta-decay – Selection rules – Nonconservation of parity – Gamma emission – Selection rules – Transition probability – Internal conversion – Nuclear isomerism

3. Nuclear Reactions

Q-values and kinematics of nuclear cross sections – Energy and angular dependence – Reciprocity theorem – Breit-Wigner formula – Compound nucleus – Resonance theory – Optical model-Shell model – Liquid drop model – Collective model

4. Interactions of radiation with matter

Mechanism of Interaction of Ionizing Radiation: Ionization and absorption of energy – Photon Beam Description - Photon Beam Attenuation – Attenuation Coefficient and mass energy attenuation coefficients – Half value layer-Narrow and broad beams-Mass, electronic and atomic attenuation coefficients-Energy transfer and energy absorption-Interactions of Photons with Matter – Coherent Scattering – Photoelectric absorption – Compton Effect-Klein –Nishina coefficients – Pair Production – Total attenuation coefficient-– Relative Importance of Various Types of Interaction

Interaction of heavy charged particles with matter. Energy loss per ion pair, primary and secondary ionization- dependence of collision energy loss on physical and chemical state of the absorber- Cerenkov radiation- electron absorption- Bremsstrahlung-range energy relation- Passage of heavy charged particles through matter-loss of collision-Brag curve-specific ionization-stopping power and restricted stopping power-Beth Bloch formula.

Interaction of neutron with matter- scattering- capture-neutron induced nuclear reaction.Neutron sources, properties, energy classification, elastic and inelastic scattering, nuclear reaction, neutron activation, radio isotope production.

5. Radiation quantities and Units

Quantities to describe a radiation beam- particle flux and fluence- Photon flux and fluence- cross section- linear and mass absorption coefficient-stopping power and LET. Activity – Curie – Becquerel. Exposure and its measurements – Roentgen, Radiation absorbed Dose – Gray – Kerma- kerma rate constant- Electronic equilibrium- relationship between kerma, exposure and absorbed dose–Relative biological effectiveness- radiation weighting factors.

Equivalent dose-effective dose- tissue weighting factors-ambient and directional equivalent dose and their relevance in dosimetry, tissue equivalence, dose commitment and collective dose.

Books for Study and Reference

1. K. S. Krane, Introductory Nuclear Physics, John-Wiley, New York (1987)
2. S. B. Patel, Nuclear Physics : An Introduction, Wiley-Eastern Limited, New Delhi (1991)
3. B. L. Cohen, Concepts of Nuclear Physics, Tata Mc-Graw Hill, New Delhi (1988)
4. H. S. Hans, Nuclear Physics : Experimental and Theoretical, New Age International Publishers, New Delhi (2001)
5. The Physics of Radiation Therapy Faiz .M. Khan, Williams & Willkinds (2003).

6. RADIATION DOSIMETRY

1.Radiation detection and Measurement

Principles of measurements of radiation and radioactivity.Gas filled Ionization chamber,proportional counters,GM counters,Scintillation detectors,semiconductor detectors,BF_3 counters for neutron detection.

TLD dosimetry: process and properties,glow curves and dose response,photon energy dependence,fading,physical form of TLD materials,residual TL and annealing for reuse,repeated read out of TLD's.TL instrumentation,ultrathin TLD's,graphite /boron carbide mixed TLD'S glow curve analysis.

2.Ionization Dosimetry

Theoritical aspects of ionization dosimetry-Bragg-Gray theory-Models and equations-practical aspects of ionization dosimetry-characteristics of ionization chambers-polarity effect-stability and collection efficiency-principles of low current measurements.

Measurement of absorbed dose: calculation of absorbed dose from exposure-Bragg-gray cavity theory-.Other methods of measuring absorbed dose: calorimetry-Chemical dosimetry-solid state methods; -Silicon diodes-Radiographic film-Radiocromic film.

3.Low and medium energy dosimetry and high energy Dosimetry

In phantom measurements –reference conditions-comparison with ICRU equations-in air measurements-comparison of two methods-Exposure and kerma calibrations(in air)-K-curves-D-curves-concept of CPE and TE-Determination of in water absorbed dose-Graphite dosimetric calibration.

Historical developments-High energy photon dosimetry-CSDM,SAM models-cfactors-development of electron beam dosimetry-concept of cavity gas calibration factor for high energy dosimetry-development of new high energy dosimetry formalism-reference depth-Gradient correction-saturation correction-average stopping power ratio-comparison of electron and photon dosimetry-electron beam dose transfer formalism.

4. Dosimeters and survey meters

Dosimeters: Primary standard dosimeters, secondary standard dosimeters, Victoreen R meter, dosimeter based on current measurements, radio isotope calibrator, multi purpose dosimeters -water phantom dosimetry systems, Brach therapy dosimeters. Calibration and maintenance of dosimeters.

Instruments for personal monitoring, digital pocket dosimeters using solid state devices, and GM counters, teledetectors, portable survey meters, gamma area (zone) alaram

monitors, contamination monitors for alpha, beta and gamma radiations, scintillation monitors for X ray and gamma radiation –neutron monitors- tissue equivalent survey meter-flux meters, dose equivalent monitors.

5. Standardization of electrons,*x*-ray and gamma rays beams

Determination of exposure and air kerma, conditions for the realization of exposure, ionization chamber for low, medium and high energy x-rays and gamma rays, determination of absorbed dose, Bragg Gray theory and its validity, Burlin's theory for measurement for radiation quantities,

Standardization of x-ray and high energy beams, design of free air chambers, characteristics of free air chambers and graphite chambers, intercomparision of standard chambers for ensuring traceability, standardization of electron beams used in radiotherapy – calibration of secondary standards.Details of IAEA and other protocols for dosimetry of photon beams.

Standardization of Brachy therapy sources and sealed source in terms their radiation output, calibration of protection level dosimeters in terms of dose equivalent units.

BOOKS FOR STUDY AND REFERENCE

1. H.E. Jones and J.R. Cunnigham, The Physics of Radiology, Charles C. Thomas. New York (1980).
2. B.H. Brown, R.H. Smallwood, D.C. Barber, P.V. Lawford and D.R. Hose, Medical Physics and Biomedical Engineering, Overseas Press India Private Limited, New Delhi (2005).
3. The Physics of Radiation Therapy Faiz .M. Khan, Williams & Willkinds (2003).
4. IAEA Technical Reports Series Number 398, Vienna 2000.
5. Advanced Medical Radiation Doseimetry, Govindharajan; Prentice Hall of India(Pvt) Ltd 1992.
6. Physics of electron beam therapy: SC Klevenhagen, Medical physics handbooks 13; Adem Hilger Ltd,Bristol and Boston (1985)

7. PHYSICS OF DIAGNOSTIC RADIOLOGY

1. Physical Principles of X- ray Diagnosis

X-Ray production, properties, Characteristic spectrum and Bremmsrahlung spectrum, X-ray tubes- X-ray tube insert, Tube housing, filtration, and collimation. X-ray generator function and components. X-ray generator circuit designs. Timing the x-ray exposure in radiography. Factors affecting x-ray emission-Quality of x-ray beams-HVL and its measurement-measurement of energy. Power ratings and heat loading. X-ray exposure ratings charts

Historical x-ray tubes; Gas tube-coolidge tube. Moderrn x-ray tubes;Stationary x-ray tube-Rotating anode x-ray tube-Grid controlled x-ray tubes. Therapeutic and industrial radiographic tubes, X-ray tubes for mobile,dental, mammography,CT and DSA applications.

2. Screen – Film Radiography

Projection radiography – Basic geometric principles.The screen-film cassette. Characteristics of screens. Chracteristics of film. The screen-film system. Contrast and dose in radiography. Scattered radiation in projection Radiography-Grid.
Film processing: Film Exposure – Film processor-manual and automatic-dark room – Processor artifacts – Other considerations – Laser Cameras – Dry processing- Processor Quality assurance.

3. Mammography & Fluoroscopy

X-ray tube design. X-ray generator and photo timer system. Compression, scattered radiation and magnification. Screen – film cassettes and film Processing. Ancillary procedures. Radiation dosimetry. Regulatory requirements.

Functionality – Fluoroscopy Imaging chain components – peripheral equipment – Fluoroscopy modes of operation – Automatic brightness Control – Image quality – Fluoroscopy suites- Radiation dose

4. Image Quality & Digital Radiography

Contrast - Spatial Resolution – Noise -Detective quantum efficiency –Contrast-detail curves- Received operating characteristic curves-

Computed Radiography – Charged Coupled Devices (CCDS)- Flat panel detectors -Digital mammography-Digital verses analog processes- implementation-patient dose considerations – Hard copy verses soft copy display- Digital image Processing- contrast verses spatial resolution in digital imaging .

5. Industrial Radiography

Industrial application of radiation: Principles of industrial radiography with x and gamma ray, radiographic exposure devices, photographic film technique, radiographic contrast, definition and sensitivity, intensifying screens and penetrameters.
Principle and measurement of thickness and level in different applications, density and moisture, hydrogen in hydrocarbons, well logging, composition analysis. Principle of operation of consumer products using radiation sources fire detector, baggage inspection systems, static eliminators, luminous paints and gas mantles. Industrial radiation processing: gamma chambers, radiation sterilization, irradiation of food and medical product

Books for Study and Reference:

1.Christensen's Physics of Diagnostic Radiology; Christensen (Lea & Febiger) B.H. Brown, R.H. Smallwood, D.C. Barber, P.V. Lawford and D.R. Hose (1990)
2.The physics of Diagnostic imaging 2nd Edition (2006),David J Dowsett,Patrick A Kenny and R Eugene Johnston; Hodder Arnold
3. Medical Physics and Biomedical Engineering, Overseas Press India Private Limited, New Delhi (2005).
4. The Essential Physics of Medical Imaging Jerrold T. Bush Berg etal, Lippincott Williams & Wilkins (2002).

8. PHYSICS OF RADIATION THERAPY

1.Overview of Clinical Radiation oncology

Cancer incidence/etiology.Cancer classification/staging-review of lymphatic drainage.Overview of treatment modalities;Surgery,chemotherapy, Radiotherapy(Tele ,Brachy,neutron,ptoton and high Z therapy) hyperthermia.

Review of pertinent radiobiology; Dose response curves,4R's,relationship of volume and time to radiation effects (TDF,alpha/beta ratio).side effects/complication.Tolerance doses for normal tissue and tumors.Role of clinical medical physicist.

2. Clinical Radiation Generators

Kilo Voltage Units-Grenz ray therapy-contact therapy, superficial therapy, orthovoltage therapy – Megavoltage therapy – Resonant Transformer, Cascade generator, Vande Graff Generator – Linear Accelerator; magnetron, klystron, x-ray beam, electron beam, beam collimation ,Gantry – Betatron – Microtron - cyclotron - Machines using radio nuclides – Co-60 unit – Heavy Particle Beams –neutrons-protons and heavy ions-Negative pions.

3. Dose Distribution, Scatter Analysis & Treatment Planning

Phantoms- Depth dose distribution-Percentage Depth Dose – Tissue air Ratio – Scatter Air Ratio – Integral Dose. Dosimetric calculations-Dose calculation parameters – Practical Applications - Other Practical methods of calculating depth dose distribution.

a). Isodose Distributions: Isodose chart – Measurement of Isodose curves –Parameters of isodose curves- Wedge Filters – combination of radiation fields- Isocentric techniques-Wedged Field Techniques - Tumor Dose Specification for External Photon Beams.

b) Patient Data, Corrections, and Setup: Acquisition of Patient Data -Treatment Simulation – Treatment Verification – Corrections for contour Irregularities – Corrections for Tissue (body) Inhomogenities – Absorbed Dose within an Inhomogenity – Tissue Compensation –Patient positioning.

c) Field Shaping, Skin Dose, and Field Separation: Field Blocks – Field Shaping – Skin dose- Separation of Adjacent Fields.

4. Electron Beam Therapy & Brachytherapy

Electron interactions- Energy Specification and Measurement – Determination of Abosrbed Dose – Characteristics of Clinical electron beams- Treatment Planning – Field Shaping – electron Arc Therapy – Total Skin Irradiation-Treatment planning algorithms.

Radioactive Sources – Radium and radium substitutes, Cesium – 137, Cobalt – 60, Iridium – 192, Iodine – 125-Gold 198-Iodine 125-Palladium-103 sources. - Calibration of Brachytherapy Sources – Checking of source integrity and uniformity- Specification of Source Strength – Exposure Rate Calibration – Calculation of Dose Distributions – Systems of implant Dosimetry - The Paterson-Parker System – The Quimby System – The Memorial System – The Paris System – Computer System – Use of Computers in Brachy therapy Dosimetry – Implantation Techniques – Dose Specification: Cancer of the Cervix – Milligram hours- Manchester system- ICRU system- Afterloading Techniques, Manual After loading - Remote Afterloading Units– Beta ray applicators .

5. Modern Radiation Therapy

HDR brachytherapy- High dose rate unit-Licensing requirements-High dose rate calibration- Treatment planning-quality assurance-clinical applications

Total Body irradiation -techniques and equipment. 3D conformal radiation therapy-Treatment planning process- Dose computation algorithms. Intensity modulated Radiation therapy (IMRT)- IMRT planning-IMRT delivery- Commissioning of IMRT - Dose calculation algorithms-clinical application.

Stereotactic Radiosurgery- basics &Techniques-Dosimetry-dose calculation algorithm-quality assurance-Clinical applications.

Computers in Treatment planning: Review of algorithms used for treatment planning computation, Photon beam, electron beam, interstitial and intracavitary therapy, Factors to be incorporated in computational algorithms, Hardware and software requirements, and cost effectiveness of TPS

Books for Study and Reference:

1. Faiz. M. Khan, The Physics of Radiationtherapy, Lippincott Williams & Wilkins, Philadelphia, 3rd edtion 2003.
2. S. Webb, The Physics of conformal radiography, Inst of Publishing, Philadelpia, 1997.
3 .S. Webb, Intensity Modulated Radiotiontherapy, Institute of Publishing, Philadelphia, 2001.
4. J. Van DYK, The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
5. S.C. Klevenhagen, Physics and dosimetry of Therapy Electron beams, Medical Physics Publishing, Madison , WI, 1999.
6 .Practical Radiotherapy planning-Dobbs (1999); Vora Medical publishers,Mumbai

SECOND YEAR

1. PHYSICS OF MEDICINE AND BIOLOGY

1. Review of statistics and probability: (a) Patient population and samples (b) Binomial,gaussion and poison distributions.

Mechanics applied to body systems: (a) Forces on the Achillstendon and hip (b) Mechanics of using a cane

Hydrostatics: (a) viscous flow in a tube (b)transport in an infinite medium (c) flow,flux and continuity (d)Particle motion in a liquid-the Longevin form of newtons second law,(e) Newtonian fluids-viscosity-stokes law

2. Diffusion: (a) Ficks first law(b)diffusion related to viscosity (c) Ficks second law and applications

Transport through semipermeable membranes; (a)Osmotic pressure (b)plasma exchange in capillaries (c) Edema: osmotic diureses:Osmotic fragibility of red blood cells(d) Volume transport ;solute transport:the artificial kindney (e) external factors on solute molecules;ionic solute and equilibrium electric fields in membranes(f) Ion movement in solution involving diffusion,solvent drag and electrical fields (g) Nernst-Plank equation and the Goldman equation

3. Nerve cell structure (a) Non myelinated and myelinated axons (b) Introduction to the electrical nature of nerve impulse transmission (c) review of electro statics

Electrodynamics emphazing relevance to nerve impulse.Conduction:current density,conductivity,kirchhoff's laws.Charge distribution in the resting nerve cell
Leakage currents across the Axon membrane in the absence of Myelination.

Resistance of the Axon.Nerve impulse and transmission across synapse (a) Application of Kirchhoff's laws to wave equation for nurve impulse transmission in myelinated axons (b) small voltage changes not involving changes in membrane conductance (electronus) (c)voltage clamp experimemts

4.Hodgkin-Huxley Model for membrane current (a) Voltage changes in the axially clamped axon following electrical stimulation as test of the Hodgkin-Huxley model.(b) solutions of the wave equation for (propagation) for non myelinated axons employing the Hodgkin-Huxley Model

Nurve impulse propagation in the myelinated axons; myeline sheath conduction and capacitance; saltatory conduction

Electrocardiograms: taking the body to be a uniform conductor

5.Kidney (a) structure of nephron (b) a physicist's view of the glomerulus

Non ionic filtration by glomerulus –transport through pores of particals having diameter of the order of pore diameter.

Theory and experiment of verniory

Biomagnetism including generation of magnetic fields by electric currents in the body and their detection,physical principle of DC SQUID

Books for Study:

1.Hobbie,Russell 1988,Intermediate physics for medicine and biology(Wiley ,NY)
2.Guyton A.C.1976 Text book of medical physiology 5 th ed (W.B.Saunders co. Philadelphia)
3.Ganong W F 1975 Review of medical physiology 7 th ed (Lange Los Altos CA)

2. BIOMEDICAL INSTRUMENTATION

1.Biosignal acquisition

Physiological signal amplifiers-isolation amplifiers-differential amplifiers-bridge amplifiers-chopper amplifiers-noises and CMRR –medical preamplifier design

2.Bioelectric signal recording

Bioelectric potentials-resting and action potentials-half cell potential-surface,needle and micro electrodes,electrical equivalent circuits-ECG,EMG,EEG recording circuits.

3.Physiological assist devices

Cardiac pace makers-natural and artificial pace makers-pace maker batteries-defibrillator-AC/DC.Synchronised defibrillator-stimulators-bladder stimulators-heart lung machine.Various types of oxygenerators-kidney machine-hemodialying units-peritonial dialysis.

4.Clinical and operation theatre equipments

Flame photometer-spectroflurophotometer-pH meters-Audiometers-endoscopes-electromagnetic and laser blood flow meters-ventilators –diathermy units-ultrasonic,micro wave diathermy techniques.

5. Biotelemetry and safety instrumentation

Design of a biotelemetry system, radiotelemetry with subcarrier-multiple channel telemetry systems-problems in implant telemetry-uses of biotelemetry-physiological effects of 50 HZ current –microshock and macro shock-electrical accidents in hospitals-devices to protect against electrical hazards.

Books for Study and Reference

1.Jacobson and Webster; Medicine and clinical engineering,Prentice Hall of India,New Delhi,1979

2.R.S.Khandpur,Hand book of biomedical instrumentation,Tata McGraw Hill,New Delhi,1990

3.M.Arumugam, Biomedical instrumendation, Anuradha publishing Co, Kumbakonam, Tamilnadu 1992.

4.Richad Aston,Principles of biomedical instrumendation and measurements,Merrill publishing Co,London,1990.

3. RADIATION BIOLOGY

1 . Action of Radiation on Living Cells

Elements of cell biology – effects of ionizing radiation at molecules and cellular levels – secondary effects -Target theory - single hit and multi hit target theory - other theories of cell inactivation - concepts of micro dosimetry - direct and indirect action - radicals and molecular products -cellular effects of radiations – Bacterial and Mammalian cell survival – application in cancer therapy, food preservation, radiation sterilization etc – Radio sensitivity at different phases of the cell cycle – inactivations - division delay - DNA. damage - depression of macromolecular synthesis - giant cells - chromosomal damage- point mutations- survival parameters- invitro and invivo experiments on mammalian ceil systems - RBE - response - modifiers- LET; oxygen, cell stage – Physical chemical and Biological factors influencing the effect of radiation - recovery mechanism radio protective and radio sensitizing chemicals- radiometric substances - chemical mutagenesis - effects of UV, microwave and other non - ionizing radiations – Physics and biological factors affecting cell survival, tumor regrowth the normal tissue tolerance, repair redistribution in the cell cycle – basis for dose fractionation in beam therapy.

2 Radiobiological Models:

Standquist Isoeffect curves – concepts of Nominal standard dose (NSD) – CRE Model – Time dose fractionation (TDF) Model and Linear Quadratic Models.

3. Somatic effects of Radiation :

Bergonis - Tribondeau law – radio sensitivity protocol of different tissues in human:LD50/30 - effect of radiation on skin - blood forming organs, lenses of-eyes, blood constituents, embryo, digestive tract, endocrine glands, gonads, dependence of effect on dose, dose rate, type and energy of radiation syndrome - effects of chronic exposure to radiation – radiation Carcinogenesis - shortening of life span risk estimates. Late effects, radiation indused carsinogenisis Stochastic and deterministic effect. Effects on embryonic and fetal development

4. Radiobiological basis of Radiotherapy:

Benign and malignant tumours, Tissue tolerance dose and tomour lethal dose,fraction, palliative and curative therapy.Tumor growth kinetics -rational of fractionation - problem of hypoxic compartment and quiescent cells - radiobiology of malignant neoplasm - solution of hypoxic cell sensitizers, hyperthermia, recourse to high LET radiation - combination of chemotherapy and Radiotherapy – chronoradio biology and its applications to get better cure - problem of tumor regression – Application of Various models in clinical Radiotherapy – Practical considerations.

5. Genetic effects of Radiations:

Threshold and linear dose - effect relationship - factors affecting frequency of radiation induced mutations recessive and dominant mutations - gene controlled hereditary diseases human data on animals and lower species - doubling dose and its influence of genetic equilibrium.

Books for Study and Reference:

1. E. J. Hall, Radiobiology for Radiologists,J. B. Lippincott Co., Philadelphia, 1987.
2. S.P. Yaremonenko, Radiobiology of Humans and animals, MIR, eublishers, Moscow,1990.
3. Basic Clinical Radio Biology : G. Gordon Shell, Arnold, 2002.

4. PHYSICS OF NUCLEAR MEDICINE

1. Production of Radiomuclides and Radio-Pharmaceuticals:

Radioactivity and nuclear transformation: Radionuclide decay terms and relationships-Activity-decay constant-Physical half life- Decay equation.Nuclear tranformation-Alpha decay-Beta decay-Electron capture-Isomeric transition.
Methods of Radiomuclide production-Reactor produced-accelerator produced--General considerations. Production of short lived radionuclides, using a generator-Principle and description.
Radiophraceuticals: Design and development considerations-Quality copntrol-Technetium-99m Labelled radiopharmaceuticals- Radioiodine labeled radiopharmaceuticals -Compounds labellled with other radionuclides-Radiopharmaceuticals for PET-Therapeutic uses of pharmaceuticals-Mis admininistration of Radiopharmaceuticals-In –vitro kit procedures-RIA kit

2. Radiation Dose, Detectors and Standardization

Radiation dose calculations-general considerations-S-factor-Radiation doses in imaging process. Detector characteristics-Types of detectors- Gas filled detectors Ion chambers-
Geiger –Proportional copunters-Muller counters– Scintillation detectors – Semi conductor detectors-single and multi channel anlysers. Pulse height spectroscopy.In Vitro radiation detection-Well type NaI (TL) Scintillation detectors-Liquid scintillation detectors-Thyroid uptake probes.Counting statistics, application of poisson's statistics, goodness fit tests, Lexide's divergence coefficients, Pearson's chi-square test and students test

Methods of measurements of radioactivity, defined solid angle and 4π β-γ coincidence counting, standardization for beta emitters and electron capture nuclides with proportional, GM and scintillation counters, standardization of gamma emitters with scintillation spectrometers, routine sample measurements, re-entrant ionization chamber methods, using (n,γ) and (n,p) reactions.

3. Nuclear Imaging- Scintilation Camera

Planar Nuclear imaging – The Anger Scintillation Camera-design and principle–collimators-Detector-Position Determining circuits-Display-Imaging with scintillation camera-principles of image formation-Performance-Design factors determining performance- Effects of scatter and attenuation on projection images-Whole body scanning and SPECT-Computers in Nuclear Imaging. Operation Characteristics: spatial resolution-Sensitivity-Uniformity and high count rate performance

4. Nuclear Imaging- Emission Tomography

Single Photon emission computed Tomography-Design and principles of operation-image acquisition- Transverse image reconstruction-Attenuation correction in SPECT-Collimators- Multi-head SPECT cameras –Performance.

Positron emission Tomography (PET)-Design and principles of operation-Design of a PET scanner-Timing of interactions and detection of coincidences-True verses Random coincidences-scatter coincidences-Two-and three dimensional data acquisition.-Transverse image reconstruction-Performance-Alternatives to dedicated PET systems-Comparison of SPECT and PET-PET –CT system.

5. Clinical Applications

Skeletal system-scanning methods-bone marrow scanning –bone mineral measurements-cerebrovascular system—functional brain imaging-CSF imaging-Thyroid and parathyroid imaging-cardiovascular system-Thallium techniques-respiratory system-perfusion agents-gastrointestinal tract Liver and spleen imaging- Genitourinary system-tumor and inflammation imaging.

Books for Study and Reference:

1.The essential Physics of Medical Imaging, Jerrold T. Bushberg etal, Lippincott, Williams & Wilkins 2002.
2.Nuclear Medicine physics; The Basics, Ramesh Chandra, Indian edision, Lippincoii Williams & Wilkins ,6th Edn,2004.
3.Physics of Nuclear Medicine, Cherry 3rd Edn, 2003,Vikas Medical book House, Mumbai

5. ADVANCED MEDICAL IMAGING PHYSICS

1. Computers in Medical Imaging

Storage and transfer of data in computers-number systems-decimal and binary form-transfer of data in digital form. Analog data and conversion between analog and digital form. Components and operation of computers-main memory-computer program and CPU—input /output bus and expansion slots-mass storage devices-keyboard and printing devices. Performance of Computer systems. Computer Software – Storage, Processing and display of digital Images.

2. Computed Tomography

Basic Principles – Geometry and historical development –different generations-Detectors and Detector arrays –xenon detectors-solid state detectors—Multi detector arrays– Details of acquisition –Single and Multiple array scanners- Tomographic Reconstruction –sinogram-Data processing-interpolation-simple back projection reconstruction-Filtered back projection-Bone kernals and soft tissue kernels-CT number – CT fluoroscopy- Digital image display – windowing and leveling- Multiplanar reconstruction-3D image display-stack mode viewing-Radiation dose –dose measurement-Dose in helical and CT fluoroscopy-Image Quality – Factors affecting image quality-Artifacts.

3. Ultra Sound

Characteristics of sound-propagation of sound- wavelength, frequency and speed-Pressure, intensity and dB scale. Interactions of Ultra sound with matter – acoustic impedence- reflection-refraction-scattering-attenuation. Transducers – Piezoelectric materials-resonance transducers-damping block-matching layer-Multi frequency transducers-transducer arrays. Beam properties- near field-far field-side lobes-spatial resolution. Image data acquisition-data acquisition systems-ADC-receiver-Echo display modes-scan converter. Image display and storage-Early B mode scanners- mechanical scanning-electronic scanning and real time display- Image storage. Biometric measurements-contrast agents-harmonic imaging-3D imaging. Image Quality and artifacts – Doppler Ultra sound –doppler frequency shift-continuous and pulsed Doppler-Duplex scanning-doppler spectral interpretation-Color flow imaging-power Doppler. Performance and Quality assurance – Acoustic power and Bio effects

4. Magnetic Resonance Imaging (MRI):

Magnetization properties – Generation and detection of MR signal-free induction decay –T1 and T2 relaxation. Pulse sequences – Spin EcoT1 weighting-spin density weighting-T2 weighting. Inversion Recovery – Gradient recalled Eco – Signal from flow – Perfusion and diffusion contrast-Magnetization transfer contrast

Localization of the MR Signal –magnetic field gradients-slice select gradient-frequency encode gradient-phase encode gradient. K- Space data acquisition and Image

reconstruction –2D data acquisition- 3D Fourier transform image acquisition – Image Characteristics – Angiography and Magnetization transfer contrast – Artifacts – Instrumentation-magnet-ancillary bequipment-quality control – Safety and Bio effects.

5. Computer Networks, Pacs and Teleradiology

Computer Networks-basic principle-local area network-large network and network linking- Long distance telecommunication links—network security. PACS and Teleradiology acquisition of digital images-network for image and data transfer-storage of images-display of images-advantage and disadvantage of PACS-security and reliability-quality control.

Books for Study and Reference:

1. The essential Physics of Medical Imaging; Jerrold. T. Bushberg et.al, Lipcontt Williams & Wilkins 2002.
2. Christensen's Physics of Diagnostic Radiology; Christensen (Lea & Febiger) B.H. Brown, R.H. Smallwood, D.C. Barber, P.V. Lawford and D.R. Hose (1990)
3. The physics of Diagnostic imaging 2nd Edition (2006),David J Dowsett,Patrick A Kenny and R Eugene Johnston; Hodder A

6. RADIATION SAFETY AND REGULATIONS

1. Radiation Hazard Evaluation and Control and Emergency Preparedness

Hazard evaluation by calculation, methods of calculation,time distance shielding, area monitoring, personal monitoring.Detection and measurement of contamination on work surface,person and samples, methods of decontamination, evaluation of radiation hazards in medical diagnostic and therapy installations,protective measure to reduce radiation exposure to staff and patients, radiation hazards in brachytherapy, departments and teletherapy departments, radioisotope laboratories and particles accelerator facilities, protective equipments, handling of patients,radiation safety during source transfer operation, special safety consideration for accelerator installations.

2. Transport of Radioactive Material

Examples of radioactive shipments for medical and industrial, research applications of radioactive sources and in connection with nuclear fuel cycle. Special form radioactive materials and non-special form radioactive materials, Al and A2 values and basis of derivation of these values, low specific activity materials and surface contaminated objects. Design and test requirements of special form radioactive material, industrial package Type IP-1,IP-2 and IP-3 Type A packaging and Type B(U)/(M) packing, transport under exclusive use and special arrangements, expected packages and fissile exception, exempt radioactive material, approval requirements for radioactive materials, packaging and shipments, requirements for preparation, forwarding, storage and transport of packages, and marking and labeling requirements, limits on Non-fixed contamination and radiation level and temperature outside packages, transport documents, emergency response requirements.

3. Planning of Radiation Installation

Of various types for different applications (X-ray diagnostic, deep therapy, telegamma ad accelerator installations, brachytherapy facilities, nuclear medicine facilities, etc.) effects of scattering, albedo, sky shine, noxious gas production, designing a shielded container for storage/transport of radioactive materials (e.g. gamma chamber, radiographic exposure device, nucleonic gauge, neutron source container etc). Emergency preparedness, emergency handling, graded approach, site emergency.

4. Radiation Protection Standards and Regulations

Need for protection, philosophy of radiation protection, basic radiation protection criteria, External and internal exposure, additive risk model and multiplicative risk model. Risk coefficients. Dose to the foetus. Dose limits for occupational exposure, for public and special exposure situations. ICRP and AERB recommendations. Basic safety standards. Source, practices, types of exposures, interventions. Atomic energy act, Radiation protection Rules, Notifications, Transport regulations, Waste disposal rules, Food irradiation rules, licensing, approval of devices, installations, sites and packages

containing radioactive material. Source of radioactive waste and classification of waste, treatment techniques for solid, liquid and gaseous effluents, permissible limits for disposal of waste, sampling techniques for air,water and solids, ecological consideration, general methods of disposal, management of radioactive waste in medical and research institutions.

5. Radiation Shielding

Shielding calculation for gamma radiation, choice of material, Primary and secondary radiation, source geometry, discrete sources, point, kemel method, introduction to Monte Carlo method, Beta shielding, Bremsstrahlung. Neutron shielding, scattering and absorption, activation of the shielding material, heat effects. Optimization of shielding, gamma, electron, neutron irradiation facilities. Transport and storage of containers for high activity sources. Shielding requirements for medical and research facilities including accelerator installations

Books for Study Reference:

1. R.F.Mould, Radiation Protection in Hospital, Adam Hilger Ltd., Bristol, 1985.
2. The essential Physics of Medical Imaging; Jerrold. T. Bushberg et.al, Lipcontt Williams & Wilkins 2002.
3. Faiz. M. Khan, The Physics of Radiationtherapy, Lippincott Williams & Wilkins, Philadelphia, 3rd edtion 2003.
4. A.Martin and S.A.Harbison, An introduction to Radiation Protection, John Wiley &'Sons Inc., New York, 1981.
5. ICRP Publications (ALL)
6. AERB Safety codes(ALL)
7. NCRP Publications(ALL)