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 Training. The course is designed to enable the knowledge and skill in Medical Physics and allied Sciences. They shall come into force from the academic year 2010-2011 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) with Mathematics as one of the ancillary subject **in Regular Study**. **The candidates who studied B.Sc.,(Physics) through correspondence and open university stream of university education are not eligible.**
***It was resolved XXXXIII dt.19.12.2011

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:

The candidate who has passed any qualifying examination as stated in Regulation No.3 above other than the Tamil Nadu Dr. MGR Medical University, Madurai Kamaraj University, University of Madras, Bharathiyar University, Bharathithasan University or any other University shall obtain an "Eligibility Certificate" from this University by remitting the prescribed fee along with the application form and required documents before seeking admission to anyone of the affiliated medical institutions. The application form is available in the University website (www.tnmmu.ac.in).

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

a) The Candidates admitted 31st May / 31st October of the Academic Year will be registered to take up their first year M.Sc.(Medical Physics)Degree course after fulfillment of the regulation.

b) All kinds of admission shall be completed on or before 31st May and 31st October and there shall not be any admission after the above date even if seats are vacant.
***It was resolved XXXXIII dt.19.12.2011

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 Training.

10. COMMENCEMENT OF THE COURSE:-

The course will commence from 1st May and 1st October of the Academic Year.
***It was resolved XXXXIII dt.19.12.2011

11. COMMENCEMENT OF EXAMINATION:

April 15th / October 15th

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.
***It was resolved XXXXIII dt.19.12.2011

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 Residency Training 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.

15. WORKING DAYS IN AN ACADEMIC YEAR : -

Each academic year shall consist of not less than 270 working days as per Regulation of this University.

Total No. of days in a year			**365 days**
No. of weekly off(Sundays)	-	52 days	
No. of Government Holidays	-	22 days	
No. of Holidays	-	21 days	
		---	95 days
Total No. of working days including			270 days
examination period			---

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.

For dissertation marks 200, Viva-voce on dissertation/Presentation mark 50 and IA 50– Minimum mark to pass 150.
* It was resolved XXXX111 S.A.B. Dated 19.12.2011.

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.

20. 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.

21. AWARD OF DEGREE :-

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

22. 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.

23. 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.

24. RETOTALLING OF ANSWER PAPERS:-

Re-totalling is allowed in the failed subjects.

25. 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 Training.

26. 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.

27. 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.

28. VACATION :-

No Vacation for Post Graduate Degree Courses of this University.
***It was resolved XXXXIII dt.19.12.2011

29. AUTHORITY TO ISSUE TRANSCRIPT :-

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

30. 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.

31. COMPULSORY RESIDENCY TRAINING :-

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

The student must produce the provisional pass certificate from the University to commence their Compulsory Residency Training. During the Compulsory Residency Training 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.

32. SUBJECTS OF STUDY :-

PROPOSED CURRICULUM FOR M.Sc., (Medical Physics)

FIRST YEAR SUBJECTS

1. Radiation Physics
2. Radiological Mathematics
3.Anatomy and Physiology and Pathology
4. Radiation Dosimetry and Standardization
5. Radiation Detectors and Instrumentation
6. Physics of Medical Imaging
7. Physics of Radiation Therapy

SECOND YEAR SUBJECTS

1. Advanced Techniques of Radiotherapy
2. Clinical Radiation Biology
3. Physics of Nuclear Medicine and Internal Dosimetry
4. Radiation Safety
5. Dissertation/Project and Viva Voce

Third Year

RESIDENCY TRAINING:

One year Residency Training in the college and hospital only.

After successful completion of one year Residency Training the candidate becomes eligible to appear for Radiological safety Officer (RSO) qualifying examination conducted by AERB in coordination with RP&AD, BARC, Mumbai

33. QUESTION PAPER PATTERN :-

Theory :

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

REVISED SYLLABUS FOR M.Sc. (MEDICAL PHYSICS)

SCHEME OF EXAMINATION

FIRST YEAR SUBJECTS

Sl. No.	Paper - Subject	Internal Assessment (IA)		Theory		Practical		Viva	
		Max	Min	Max	Min	Max	Min	Max	Min
1.	Radiation Physics	50	25	100	50	-	-	-	-
2.	Radiological Mathematics	50	25	100	50	-	-	-	-
3.	Anatomy and Physiology and Pathology	50	25	100	50	-	-	-	-
4.	Radiation Dosimetry and Standardization	50	25	100	50	-	-	-	-
5.	Radiation Detectors and Instrumentation	50	25	100	50	-	-	-	-
6.	Physics of Medical Imaging	50	25	100	50	-	-	-	-
7.	Physics of Radiation Therapy	50	25	100	50	100	50	50	25

SECOND YEAR SUBJECTS

Sl. No.	Paper - Subject	Internal Assessment (IA)		Theory		Practical		Viva	
		Max	Min	Max	Min	Max	Min	Max	Min
1.	Advanced Techniques of Radiotherapy	50	25	100	50	100	50	50	25
2.	Clinical Radiation Biology	50	25	100	50	-	-	-	-
3.	Physics of Nuclear Medicine and Internal Dosimetry	50	25	100	50	-	-	-	-
4.	Radiation Safety	50	25	100	50	-	-	-	-

Evaluation of Dissertation	200
Viva/Presentation	50
IA	50
Total	300
Passing Minimum	150

THIRD YEAR – RESIDENCY TRAINING

The postings in the Residency Training is as follows:

S.No.	Subject	Period
1	Medical Physics Lab	2 months
2	Radiation Safety	1 month
3	Radiotherapy	6 months
4	Mould and Immobilization Technique	1 month
5	Diagnostic Radiology	1 month
6	Nuclear Medicine	1 month
	Total	12 months

Detailed syllabus for revised subject of study

(Number of Lectures shown against each topic is indicative only)

First Year

1. RADIATION PHYSICS

Introduction 15 hours

Physical quantities measurements and units- force, work and energy- Temperature and heat

Atomic structure

The structure of the atom – Rutherford's Nuclear Atomic model – Bohr' Atomic model - Ionization and excitation – Electronic configurations of atoms - Atomic number- Atomic Mass number and energy units- nuclear energy levels. Discovery of Electron- Motion of Electron in electric fields – Motion of Electron in a Magnetic field – Motion of Electron in a crossed electric and magnetic fields – Mass of an electron.

Atomic nucleus 10 hours

Theory of nuclear composition – Proton-Neutron theory of nuclear composition – general properties of a nucleus – packing fraction – mass defect and atomic binding energy – significance of average binding energy – nuclear forces – meson theory of nuclear forces – nuclear models – liquid model – nuclear shell model

Electricity and Magnetism 10 hours

Electric current – Resistance and Ohm's law, circuit laws- Electric and magnetic fields – Coulomb's law of Electric Force – Electron volt- Electrical energy and power – Magnetism and Electricity – Laws of Magnetic Force – magnetic Field Strength or Magnetizing Force – magnetic Flux Density - force on a current carrying conductor Motion of a charged particle in transverse magnetic field - Electromagnetic induction – Mutual induction and Self-induction - Alternating currents and Transformers –Autotransformers.

Electromagnetic Radiation: - 5 hours

Wave model – Quantum Model– visible light and fluorescence particulate radiation – inverse square law.

Natural and Artificial radioactivity 20 hours

Radioactivity – General properties of alpha, beta and gamma rays – Laws of radioactive disintegration – Radioactive decay constant – Half-life period – average life – Isotopes, Isobars, Isomers – Isotones and Isodiapheres - Natural radioactive series – Radioactive equilibrium –Radioactive decay - α particle decay – β particle decay – Theory of beta decay – Gamma emission – Electron capture – Internal conversion – Nuclear isomerism – Artificial radioactivity - Nuclear reactions –α, p reaction - α, n reaction- Proton bombardment - deuteron bombardment- neutron bombardment – photo disintegration – Activation of nuclides - Elementary ideas of fission, fusion and nuclear reactors.

Radiation quantities and Units 15 hours

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 (RBE)- radiation weighting factors.

Interaction of Radiation with Matter 10 hours

Interaction of electromagnetic radiation with matter: Ionization – Photon beam exponential attenuation – Rayleigh scattering – Photoelectric effect - Compton effect - energy absorption – Pair production – Attenuation, energy transfer and mass energy absorption coefficients – Relative importance of various types of interactions.

Interaction of charged particles with matter: 15 hours

Classical theory of inelastic collisions with atomic electrons – Energy loss per ion pair by primary and secondary ionization – Dependence of collision energy losses on the physical and chemical state of the absorber – Cerenkov radiation – Electron absorption process – scattering excitation and ionization – Radiative

collision – Bremmstrahlung – Range energy relation – Continuous slowing down approximation (CSDA) – straight ahead approximation and detour factors – transmission and depth dependence methods for determination of particle penetration - empirical relations between range and energy – Back scattering.

5 hours

Passage of heavy charged particles through matter – Energy loss by collision – Range energy relation – Bragg curve – Specific ionization – stopping power – Bethe Bloch Formula. Interaction of neutrons with matter - scattering – capture – Neutron induced nuclear reactions.

Books for references

1. R.D. Evans, Atomic Nucleus
2. Preston M.A. Physics of Nucleus
3. Lapp R.E. Nuclear Radiation Physics
4. Segre E. Experimental Nuclear Physics
5. B.L. Theraja Modern Physics
6. Slack L. Radiations from Radioactive Atoms
7. Oliver R. Radiation Physics in Radiology
8. Crouthamel C.E. Applied Gamma – ray Spectrometry

2. RADIOLOGICAL MATHEMATICS

10 hours

Units of measurement related to Medical Physics, Radiotherapy and Radiology – notation – fraction and ratios – reciprocal values – logarithms – proportional quantities – graphs – linear graphs - nonlinear graphs - vectors and scalars – calculus – volumes and surfaces – trigonometry – oscillations and waves – Geometry - symmetry – line symmetry and mirror symmetry - percentage of deviation – decay constant calculation- decay chart preparation and tabulation for cobalt-60, Caesium-137, Iridium-192.

Probability, Statistics and Errors 15 hours

Probability – addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data.

Basic ideas of statistical distributions frequency distributions, average or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, median, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis.

Application to radiation detection – uncertainity calculations, error propagation, time distribution between background and sample, minimum detectable limit.

Binomial distribution, Poisson Distribution, Gaussian distribution, exponential distribution – additive property of normal variates, confidence limits, Bivariate distribution, Correlation and Regression, Chi-square distribution, t-distribution, F-distribution.

Counting and Medical Statistics 10 hours

* It was resolved XXXX111 S.A.B. Dated 19.12.2011.

Statistics of Nuclear counting – Application of Poisson's statistics – Goodness-of-fit tests – Lexie's divergence co-efficients - Pearson's Chi-square test and its extension – Random fluctuations Evaluation of equipment performance – Signal-to-noise ratio - selection of operating voltage – Preset of rate meters and recorders – Efficiency and sensitivity of radiation detectors – Statistical aspects of gamma ray and beta ray counting – Special considerations in gas counting and counting with proportional counters – statistical accuracy in double isotope technique.

Sampling and sampling distributions – confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis.

Numerical Methods 20 hours

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

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

Computational Tools and Techniques 10 hours

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

Books for References

1. Hoffman, Numerical Methods for Engineers and scientists – 2nd Edition Revised and expanded,.
2. A.C. Bajpai, I.M. Calus and J.A. Fairley Numerical methods for engineers and scientists – a student's course book, John Wiley & sons
3. Band W. Introduction to Mathematical Physics
4. Croxton – elementary statistics
5. Dahlberg G. Statistical Method of medical & biology students
6. Krasnor m.L. Ordinary differential equation

3. ANATOMY, PHYSIOLOGY and PATHOLOGY

Definitions and surface anatomy: 15 hours

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.

Digestive system & Circulatory system: 10 hours

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.

Respiratory & Endocrine system: 15 hours

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.

Reproduction system & Nervous system: 5 hours

(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

Excretory system & Sensory system: 5 hours

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

Radiographic anatomy and diseases:- 20 hours

Anatomy and physiology as applied to radiodiagnosis and radiotherapy – X-ray anatomy –CT/MRI anatomy-surface anatomy applied to RD and RT – introduction to the nature of diseases and trauma-inflammation and infection. Anatomy and Physiology as applied to radiodiagnosis and radiotherapy – Structure and function of organs and systems and their common diseases: Skin, Lymphatic System, Bone and muscle, nervous, endocrine, cardiovascular, Respiratory, Digestive (Gastro-Intestinal) Urinary, Reproductive, Eye and ear.

Anatomy of human body, nomenclature and surface anatomy, Radiographic anatomy (including cross sectional anatomy) – identify the different organs/structures on plain x-rays, CT scans and other available imaging modalities. Normal anatomy and deviation for abnormalities.

Pathology: 20 hours

The Normal Cell:- Cell membrane – Nucleus – Cytoplasm with its organelles- Functions- Nucleus – chromatin – Functions Nucleolus function

Cytoplasmic Organelles:- Structures and Function – Mitochondria- Lysosome- Endoplasmic Recticulum-golgi apparatus –Microtubules – Microfilaments

Cell response to Injury:- Mechanism of cell injury – Degeneration – Necrosis – Types of Necrosis

Inflammation:- Definition- Acute inflammation – chemical mediators of inflammation-Chronic inflammation – Healing – Regeneration- complication of wound healing - Injury

Genetics and Disease:- Genetics – Definition – Somatic- disorder – chromosomal abnormal- gene mutations.

Immunity and Resistance to infection:- Surface defence mechanisms- Skin-Oropharyngeal – gastrointestinal tract – Respiratory tract-urinary tract- vagina-conjunctiva-Non specific immunity – cells of immune system - Antigens Macrophages, Lymphocytes - plasma cell, Immunoglobulin -Immunodeficiency

Growth disorders:- Definitions: Hyperplasia- Hypertrophy- Atrophy-Metaplasia-Dysplasia- Neoplasia-Tumors – Benign-Malignant- Classification and nomenclatures of Tumors – Growth and spread of Tumors – Modes of spread of malignant tumors – Carcinoma-in-situ – Carcinogensis- Mechanism of carcinogenesis

Etiology of Cancer: - Physical, Chemical, Biological, Hormonal, Hereditary cancer and Immunity –Systemic effects of Neoplasia- Cancer pattern-incidence in India

Radiation Injury:- Effects of total body injury – Immediate effects – gastro-intestinal syndrome – Hematological syndrome- Late effects

BOOKS FOR 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

4. RADIATION DOSIMETRY AND STANDARDIZATION

Radiation Quantities and Units 10 hours

Radiation quantities and units – Radiometry – Particle flux and fluence – Energy flux and fluence – Cross section – Linear and mass attenuation coefficients – Mass energy transfer and mass energy absorption coefficients – stopping power – LET – Radiation chemical yield – W value – Dosimetry – Energy imparted – Absorbed dose – Kerma - Exposure – Air Kerma rate constant(AKR) – Charge particle equilibrium (CPE) – Relationship between Kerma, absorbed dose and exposure under CPE – Dose equivalent – Ambient and directional dose equivalents [(H*(d) and H'(d)} – Individual dose equivalent penetrating Hp(d) – Individual dose equivalent superficial Hs(d)

Radiation Sources 5 hours

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

Dosimetry & Standardisation of X and Gamma Rays Beams 25 hours

Standards – Primary and Secondary Standards, Traceability, Uncertainty in measurement . Charged particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/Exposure. Limitations of FAIC. Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation. Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of D_{gas}, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General Definition of calibration factor – N_x, N_k, $N_{D, air}$, $N_{D, W.}$ IAEA TRS277: various steps to arrive at the expression for D_w starting from Nx. TRS398: $N_{D, W, Q}$: $N_{D, W}$: $K_{Q,Q0}$, K_Q Derivation of an expression for $K_{Q,Q0}$ Calorimetric standards – Intercomparison of standard.

Measurement of Dw for External beams from Cobalt-60 teletherapy machines: Reference conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for Machine timing error, procedure for evaluation of Temperature and pressure correction. Thermometers and barometer. Measurement of temperature and pressure. Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. Parallel plate, cylindrical and spherical ion chambers, Ksat. Two voltage method for continuous and pulsed beams, polarity correction. Measurement of Dw for high-energy photon beams from Linear Accelerators: Beam quality, beam quality index, beam quality correction co-efficient, Cross calibration using intermediate beam quality. Quality Audit programmes in Reference and Non-Reference conditions.

Standardization of brachytherapy sources – Apparent activity – Reference Air Kerma Rate – Air Kerma strength 0 Standards for HDR Ir-192 and Co-60 sources – standardization of I-125 and beta sources – IAEA TECDOC 1274 – room scatter correction. Calibration of pπrotection level instruments and monitors.

Neutron Standards and Dosimetry 10 hours

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 & multispheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators.

Standardization of Radionuclides 10 hours

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

Radiation Chemistry and Chemical Dosimetry 15 hours

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

Books for References

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. RADIATION DETECTORS AND INSTRUMENTATION

Medical Electronics 10 hours

Semiconductor diodes – JFET – MOSFET – Integrated Circuits – Operational amplifiers (OPAM) and their characteristics – Differential Amplifier – Operational amplifier systems OPAM applications – Addition, Subtraction, Integration and Differentiation – Active amplifiers – Pulse Amplifiers – Decoders and Encoders – Microprocessors and associated peripherals – Power supplies – Regulated power supplies using ICs – AC-DC converter and RF power supplies – Switching mode power supplies – AC regulators.

Principles of Radiation Detection 25 hours

Principles of Radiation Detection and measurement – Basic Principles of radiation detection – Gas filled detectors – ionization chambers – Theory and design – construction of condenser type chambers and thimble chambers – Gas multiplication – proportional and GM counters – Characteristics of organic and inorganic counters – Dead time and recovery time – scintillation detectors – Semiconductor detectors – Chemical systems – Radiographic and Radiochromic films – Thermolumenescent Dosimeters (TLD) – Optically stimulated Luminescence dosimeters (OSLD) – Radiophotoluminescent dosimeters – Neutron Detectors – Nuclear track emulsions for fast neutrons – Solid State Nuclear track (SSNTD) detectors – Calorimeters – New Developments.

Radiation measuring & Monitoring Instruments 30 hours

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

Instruments for personnel monitoring – TLD badge readers – PM film densitometers – Glass dosimeter readers – Digital pocket dosimeter using solid state devices and GM counters – Teletector – Industrial gamma radiography survey meter – Gamma area (Zone) alarm monitors – contamination monitors for alpha, beta and gamma radiation – Hand and Foot monitors – Laundry and Portal Monitors – Scintillation monitors for X and gamma radiations – Neutron monitors, tissue equivalent survey meters – Flux meter and dose equivalent monitors – pocket neutron monitors – Teledose system.

Instruments for counting and spectrometry – Portable counting systems for alpha and beta radiation – Gamma ray spectrometers – Multichannel Analyser – Liquid scintillation counting system – RIA counters – whole body counters – Air Monitors for radioactive particulates and gases. Details of commercially available instruments and systems.

Books for References

1. Price W.J. Nucleus Radiation detection
2. Stepanor B.J. Theory of Luminescence
3. Glenn F Knoll. Radiation detection and Measurement
4. Albert Paul Malvino. Electronics principles
5. Robert L. Boylestad. Electronics devices and circuit theory
6. Paul – Horowitz. Art of Electronics
7. Greiner R.A. Semiconductor devices and Application
8. Crawford R.H. MOSFET in circuit design

6. PHYSICS OF MEDICAL IMAGING

X-ray Generators 10 hours

Discovery – Production – Properties of X-rays – Characteristics and continuous spectra – Design of hot cathode X-ray tube – Basic requirements of Medical diagnostic and therapeutic radiographic tubes – Rotating anode tubes – Hooded anode tubes – Rating of tubes – safety devices in X-ray tubes – Ray proof and shock proof tubes – Insulation and cooling of X-ray tubes – Mobile and dental units – faults in X-ray tubes – Limitations on loading.

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

Principles of X-ray Diagnosis & Conventional Imaging 25 hours

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

Radiography techniques: Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection and slices selected for imaging, objectives of radio-diagnosis, patient dose Vs Image quality.

Filtration: Inherent and added filters, purpose of added filters, beryllium filters, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolium, molybdenum)

Scatter reduction : Factors influencing scatter radiation, objectives of scatter reduction, constrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders & collimators), grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique.

Intensify screens: Function of intensifying screens, screen function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare earth screens.

Radiographic Film: Components of Radiographic Film, physical principle of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.) QA of film developer.

Image quality: Image quality parameters: sources of un-sharpness, reduction of un-sharpness factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution (point spread function (PSF), line spread function (LSF), edge spread function (ESF), modulation transfer function (MTF), focal spot size evaluation.

QA of conventional diagnostic X-ray equipment: Purpose of QA, QA protocols, QA test methods for performance evaluation of x-ray diagnostic equipment

Digital x-ray imaging and computed tomography 10 hours

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

Magnetic Resonance Imaging (MRI) 10 hours

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

Ultrasound Imaging 5 hours

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

Books for References:

1. Curry,T.S. Dowdey,J.E. Murry,R.C,(1990), Christensen's introduction to the Physics of diagnostic radiology, 4th edition, Philadelphia,Lea& Febiger
2. Bushberg,S.T; Seibert,J.A; Leidholt,E.M & Boone,J.M.(1994), The essential Physics of Medical imaging, Baltimore, Williams & Wilkins
3. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R. The Physics of Diagnostic imaging
4. Johns,H.E.& Cunningham,J.R, The Physics of radiology, 4th edition
5. Hendee,W.R. & Ritenour,R.(1993) Medical Imaging Physics, 3rd edition
6. Dendy,P.P. & Heaton,B. Physics for diagnostic radiology, 2nd edition
7. E.Seeram, X-ray imaging equipment, An introduction
8. Hashemi,R.H. Bradley, W.G;& Lisanti C.J. MRI the basics
9. RF Farr and PJ Allisy-Roberts Physics for Medical Imaging
10. Sprawls,P; Magnetic resonance imaging principles, methods and techniques
11. Chesney,D.N. & Chesney,M.O. X-ray equipment for student radiographers
12. Chesney,D.N. & Chesney,M.O. Radiographic imaging

7. PHYSICS OF RADIATION THERAPY

Beam Therapy 30 hours

Kilo voltage therapy X-ray Units -Grenz ray therapy-contact therapy, superficial therapy, orthovoltage, deep therapy– spectral distribution of kV x-rays and effect of filtration – thoraeus filter – output calibration procedure.

Mega voltage therapy units: Construction and working of telecobalt units - source design – beam collimation and penumbra – trimmers and breast cones -Beam shutter mechanisms**:-** Mercury shutter – pneumatic pressure system – rotating wheel shutter system. Beam direction devices**:-** Front and back pointers – pin and arc **-** Isocentric gantry **-** Design and working of medical electron linear accelerators – beam collimation – asymmetric collimator – multileaf collimator – dose monitoring – electron contamination. Output calibration of Cobalt-60 gamma rays, 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, gamma rays, MV x-rays and electron beams. Radiotherapy simulator and its applications. CT and virtual simulations.

Particle Accelerators 10 hours

Particle accelerators for medical and research applications – The Resonant transformer – Cascade generator – Van De Graff generator – Pelletron – Cyclotron – Betatron – Synchro-Cyclotron – Linear Accelerator – Klystron and magnetron – Traveling and standing Wave Acceleration – Microtron – Electron Synchrotron-Proton synchrotron. Details of accelerator facilities in India.

20 hours

Central axis dosimetry parameters: Phantoms - Tissue equivalent phantoms - Percentage depth doses (PDD), Tissue air ratio (TAR), Back scatter factor/Peak scatter factor (BSF/PSF)– Tissue phantom ratio (TPR) – Tissue maximum ratio (TMR) – Collimator scatter factor, Phantom scatter factor and total scatter factors. Relationship between TAR and PDD and its applications – relationship between TMR and PDD and its applications. SAR, SMR, off axis ratio and Field factor. Build-up region and surface dose. . Radiation field analyzer (RFA). Description and measurement of isodose curves/charts. Dosimetry data resources.

15 hours

Beam modifying and shaping devices: Wedge filters – design of wedge filters –wedge isodose angle –wedge transmission factor – wedge system- universal, motorized and dynamic wedges –wedge field techniques - shielding blocks - field shaping – custom blocking – independent jaws – multileaf collimators – Tissue compensation – design of compensators - skin dose and factors influencing – separation of adjacent fields –methods of field separation – field matching - Treatment planning in teletherapy – SSD and SAD set ups – two and three dimensional localization techniques – contouring – simulation of treatment techniques – field arrangements – single, parallel opposed and multiple fields – corrections for tissue inhomogeneity, correction for contour irregularities 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.

5 hours

Tumor dose Specification for External Photon Beams:- Gross Tumor volume(GTV),Clinical target Volume(CTV),Internal target volume(ITV),Planning Target Volume(CTV) and Organ at risk(OAR) – Treated volume, Irradiated volume, Maximum target Dose, Minimum Target Dose, Mean Target dose, Median Target dose, Modal target dose, Hot spots - ICRU 50 and 62

Patient positioning: general guide lines – XYZ method of isocenter set-up

10 hours

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

5 hours

Particulate beam therapy: Relative merits of electron, neutron, x-ray and gamma ray beams – Neutron capture therapy – heavy ion therapy.

10 hours

Quality assurance in radiation therapy: precision and accuracy in clinical dosimetry – quality assurance protocols for telecobalt, Medical Linear Accelerator and radiotherapy simulators – IEC requirements – acceptance, commissioning and quality control of telecobalt, Medical Linear accelerator and radiotherapy simulators. Portal and in-vivo dosimetry. Electronic portal imaging devices (EPID).

Brachytherapy 15 hours

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

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

Brachytherapy treatment planning: CT/MR based brachytherapy planning – forward and inverse planning – DICOM image import/export from OT – Record & verification.

Computers in Treatment Planning 10 hours

Scope of computers in radiation treatment planning – Review of algorithms used for treatment planning computations – pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam and brachytherapy – Factors to be incorporated in computational algorithms. Plan optimization – direct aperture optimization – beamlet optimization – simulated annealing – dose volume histograms(DVH) – Indices used for plan comparisons

– Hardware and software requirements – beam & source library generation. Networking, DICOM and PACS. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

Books for References

1. Faiz M.Khan, The Physics of Radiation Therapy, 4th edition
2. H.E. Johns and Cunningham, The Physics of radiology
3. Faiz M.Khan, Roger A. Potish, treatment Planning in radiation Oncology
4. Walter and Miller's Textbook of Radiotherapy by C.K.Bomford, I.H.kunkler

Revised subject of Study

Second Year

1. ADVANCED TECHNIQUES OF RADIOTHERAPY

10 hours

Three –dimensional Conformal Radiation Therapy(3DCRT): Treatment planning process – imaging data – computed tomography – magnetic resonance imaging – image registration – image segmentation –field multiplicity and collimation – plan optimization and evaluation – Doe volume histogram(DVH) – Dose computation algorithms

5 hours

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

10 hours

Stereotactic radiosurgery /radiotherapy (SRS/SRT) – cone and mMLC based X-knife – Gamma Knie – immobilization devices for SRS/SRT – dosimetry and planning procedures – Evaluation of SRS/SRT treatment plans – QA protocols and procedures for X and Gamma Knife units – Patient specific QA. Physical, Planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy.

15 hours

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

5 hours

Prostate implants: Seed implants – permanent implants – temporary implants - radioactive sources Au-198, I-125, Pa-103 – dosimetry system – source calibration – dose computation – HDR implants

5 hours

Intravascular brachytherapy: Introduction – arterial anatomy – angioplasty and restenosis – target volume – treatment techniques – radioactive sources- β ray sources strontium-90, yttrium-90,phosphorus-32 – gamma ray HDR sources iridium-192 – radiation delivery system – dosimetry – dose calculation formalisms- catheter based gamma emitters – catheter based beta emitters – radioactive liquid filled balloons – measurement of dose distribution – sources calibration – quality assurance program

10 hours

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

5 hours

Ocular brachytherapy: using photon and beta sources– AAPM TG 60 protocol. Electronic brachytherapy (Axxent, Mamosite, etc.).

Books for References

1. S.Webb, The physics of three dimensional radiation therapy
2. S.webb, The Physics of Conformal radiotherapy
3. S.Webb, Intensity Modulated radiation therapy
4. S.K.Jani, CT simulation for radiotherapy
5. S.H. Levit.J.A.Purdy,C.A. Perez and S.Vijayakumar, Technical Basis of Radiation therapy Practical Applications 4th edition
6. J.Van Dyk, The Modern Technology of Radiation Oncology
7. S.C.Klevenhagen Physics and dosimetry of therapy electron beams
8. Thomas Bortfeld, Rupert Schmidt- Ullrich, Wilfried De Neve, David E Wazer. Image Guided IMRT Springer Berlin Heidelberg, 2006
9. D.Balstas,L. sakelliou and N.Zamboglou, The Physics of Modern Brachytherapy for oncology

2. CLINICAL RADIATION BIOLOGY

Cell Biology 10 hours

Cell physiology and biochemistry – structure of the cell – Types of cell and tissue, their structures and functions – Organic constituents of cells – Carbohydrates, fats, proteins and nucleic acids – Enzymes and their functions – Functions of mitochondria, ribosomes, golgibodies and lysosomes – Cell metabolism – DNA as concepts of gene and gene action – Mitotic and meiotic cell division – Semi conservative DNA synthesis, Genetic variation crossing over, mutation, chromosome segregation – Heredity and its mechanisms.

Interaction of Radiation with Cells 15 hours

Action of radiation on living cells – Radiolytic products of water and their interaction with biomolecule – nucleic acids, proteins, enzymes, fats – Influence of oxygen, temperature – Cellular effects of radiation – Mitotic delay, Chromosome aberrations, mutations and recombinations – Giant cell formation, cell death recovery from radiation damage – potentially lethal damage and sublethal damage recovery – pathways for repair of radiation damage. Law of Bergonie and Tribondeau.

Survival curve parameters – Model for radiation action – Target theory – Multihit, Multitarget – Repair misrepair hypothesis – Dual action hypothesis – Modification of radiation damage – LET, RBE, dose rate, dose fractionation – Oxygen and other chemical sensitizers – Anoxic, hypoxic, base analogs, folic acid and energy metabolism inhibitors – Hyperthermic sensitization – Radio-protective agents.

Biological effects of Radiation 15 hours

Somatic effects of radiation – Physical factors influencing somatic effects – Dependence on dose, dose rate, type and energy of radiation, temperature, anoxia – Acute radiation sickness – LD 50 dose – effect of radiation on skin and blood forming organs, digestive tract – sterility and cataract formation – Effects of Chronic exposure to radiation – Induction of Leukaemia – Radiation Carcinogenesis – Risk of Carcinogenesis – Animal and human data – Shortening of life span – In-utero exposure – Genetic effects of radiation – Factors affecting frequency of radiation induced mutations – Dose-effect relationship – first generation effects – Effects due to mutation of recessive characteristics – Genetic burden – prevalence of hereditary diseases and defects – Spontaneous mutation rate – Concept of doubling dose and genetic risk estimate.

Clinical Aspects of Medical Imaging & Radiation Oncology 20 hours

Radiation Therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy and Radionuclide Therapy, Benign and malignant disease, Methods of spread of malignant disease, staging and grading systems, Treatment intent – Curative and Palliative, Cancer prevention and public education and Early detection & Screening.

Site specific signs, symptoms, diagnosis and management: Head and Neck ,Breast, Gynaecological, Gastro-Intestinal tract, Genito-Urinary, Lung and Thorax, Lymphomas & Leukemias & Other cancers including AIDS related Cancers.

Patient management on treatment – side effects related to radiation and dose – Acute & Late – monitoring and common management of side effects – information and communication.

Professional aspects and role of medical Physicists: General patient care – Principles of professional practice – Medical terminology – Research & Professional writing – patient privacy – Ethical and cultural issues. Legal aspects – Confidentiality, informed consent, Health and safety.

Biological Basis of Radiotherapy 10 hours

Physical and biological factors affecting cell survival, tumour regrowth and normal tissue response – Non-conventional fractionation scheme - 5Rs in Radiobiology and their effect in the cell cycle – High LET radiation therapy.

Time Dose Fractionation 15 hours

Time Dose Fractionation – Basis for dose fractionation in beam therapy – Concepts for Nominal Standard Dose (NSD), Roentgen equivalent therapy (RET) – Time dose fractionation (TDF) factors and cumulative radiation effect (CRE) – Gap correction, Linear and Linear Quadratic models- tumor control probability (TCP) and normal tissue complication probability (NTCP).

Books for References

1. Meschan. Normal Radiation Anatomy
2. Hollinshead W.H. text Book of Anatomy

3 .PHYSICS OF NUCLEAR MEDICINE AND INTERNAL DOSIMETRY

Physics of Nuclear Medicine 10 hours

Introduction to Nuclear Medicine: Unsealed Sources, Production of Radionuclide used in Nuclear Medicine, Reactor based Radionuclides, Accelerator based Radionuclides, Photonuclear activation, equations for Radionuclide production, Radionuclide Generators and their operation principles. Various usages of Radiopharmaceuticals.

5 hours

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

10 hours

Gamma Imaging: Other techniques and Instruments; The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera/Scintillation Camera; System components, Detector system and Electronics, Different types of Collimators, Design and Performance Characteristics of the Converging, Diverging and Pin hole Collimator, Image Display and Recording Systems, Digital image Processing Systems, Scanning Camera, Limitation of the Detector System and Electronics.

15 hours

Different Imaging Techniques: Basic Principles, Two dimensional Imaging Techniques, Three Dimensional Imaging Techniques – Basic principles and problem, Focal Plane Tomography, Emission Computed Tomography, Single Photon Emission computed Tomography(SPECT), Positron Emission Tomography(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, Other requirements or Sources of Error.

In-vitro Technique : RIA/IRMA techniques and its principles 10 hours

Physics of PET and Cyclotron: Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector and scanner Design, Date Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes produced and their characteristics.

Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment. Radiation Synovectomy and the isotopes used. Concept of Delay Tank and various Waste Disposal Methods used in Nuclear Medicine.

Planning and Shielding Calculations during the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

Internal Dosimetry 15 hours

Internal Radiation Dosimetry: Difference Compartmental Model; Single Compartmental Model, Two Compartmental Model with Back Transference, Two Compartmental Model without Back Transference. Classical Methods of Dose Evaluation; Beta particle Dosimetry; Equilibrium Dose Rate Equation, Beta Dose calculation, Specific Gamma Ray constant, Gamma Ray Dosimetry, Geometrical Factor calculation, Dosimetry of Low Energy Electromagnetic Radiation.

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

Books for References

1. Ramesh Chandra, Nuclear Medicine Physics 5th edition , Lea & Febiger, Philadelphia
2. Antonto Fernando Goncalves Rocha and John Charles Harbet, Text book of Nuclear Medicine: Basic science
3. Patil J.Early.M.A. Razzak and D.Bruces Sodee Text book of Nuclear Medicine Technology,The C.V. Mosby Company
4. A.L. Baert and K.Sartor, Diagnostic Nuclear Medicine, 2nd edition, springer
5. Gopal B.Saha, Fundamental of Nuclear Pahrmacy 5th edition, spinger
6. Dale L. Bailey, David W. Townsend, Peter E. Vaik and Michael N. Maisey and Winfried Brenner, Nuclear Medicine Therapy, Informa Health care J.F. Fowler, Nuclear Particles in cancer treatment, Adam Hilger Ltd, Philadelphia, 1981

4. RADIATION SAFETY

Radiation Protection Standards 15 hours

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – International Commission on Radiological Protection and its recommendations – The system of Radiological Protection – Justification of Practice, Optimisation of protection and individual dose limits – Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – concepts of collective dose – Potential exposures, dose and dose constraints – system of protection for intervention – categories of exposures – occupational, public and medical exposures – permissible levels for neutron flux – factors governing internal exposure – Radionuclide concentrations in air and water – ALI, DAC and contamination levels.

Principles of Monitoring and Protection 10 hours

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

Safety in the Medical uses of Radiation 25 hours

Planning of medical radiation installations – General considerations – Design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories.

Evaluation of radiation hazards in medical diagnostic, therapeutic installations – Radiation monitoring procedures – Protective measures to reduce radiation exposure to staff and patients – Radiation hazards in brachytherapy departments 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.

Safety in Industrial, Agricultural and Research uses of Radiation 5 hours

Use of ionizing radiation in irradiator, industrial radiography, nucleonic gauging, well logging and research such as medical research, industrial research and agricultural research.

Radioactive Waste Disposal 5 hours

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

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

Transport of Radioisotopes 5 hours

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

Legislation 5 hours

Physical protection of sources – Safety and security of sources during storage, use, transport and disposal – security provisions: administrative and technical – security threat and graded approach in security provision.

National legislation – Ragulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable Safety Codes, Standards, Guides and Manuals – Regulatory Control – Licensing, Inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers (RSO) and Radiation workers – National inventories of radiation sources – Import, Export procedures.

Radiation Emergencies and their Medical Management 5 hours

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.

Books for References

1. Herman Cember. Introduction to Health Physics
2. Atomic Energy Act 1962
3. AERB Radiation Protection Rules 2004
4. ICRP 1990 Recommendation
5. ICRP 2007 Recommendation
6. IAEA Basic safety standards 115, 1997
7. Shapiro T. radiation Protection
8. Mckenzie. Radiation Protection in radiotherapy
9. Mawson C.A. management of Radioactive wastes.

List of Practical for the course of M.Sc (Medical Physics) Regulation 2010 – 2011

First year study:

1. Determination of half-value thickness (HVT) and linear attenuation coefficient (μ)
2. Verification of inverse square law
3. Calibration check of a therapy level dosimeter against calibrated ion chamber
4. Determination of plateau and resolving time of a GM counter and its application in measurement of beta source activity
5. Range of beta particles measurement
6. Backscattering of beat particles and its applications
7. Study of voltage and current characteristics of an ion chamber
8. Statistics of radioactive counting
9. Calibration check of survey instrument and pocket dosimeters
10. Teletherapy manual treatment planning procedures for open field for various beam combination, beam modifier and inhomogenity correction
11. Output measurement of therapy beam using radio chromic/EDR film/Fricke dosimeter
12. Calibration TL phosphor & TLD reader and its use in dose distribution measurements.
13. Doserate measurement of teletherapy machine in air medium using ion chamber/FBX dosimeter
14. Calibration of a TLD personnel monitoring badge, dose evaluation and risk estimate
15. Characteristics of a flow counter and beta activity measurement
16. Measurement of leakage/ stray radiation
17. Study of timer linearity of radiotherapy equipments
18. Characteristics of a radiographic film and image
19. Study and calibration of thyroid uptake measurement unit
20. Output measurement of cobalt-60 photon beams used in radiotherapy treatment
21. RMM measurement of cobalt-60 source

22. Determination of percentage depth dose of cobalt-60 photon beams
23. Physical integrity check of brachytherapy sources
24. Calibration of high activity brachytherapy sources.
25. AKS/RAKR measurement of an HDR brachytherapy source using well type and cylindrical ionization chambers
26. Verification of the transport index of brachytherapy source transport package.
27. Testing of safeness of darkroom

2. Second year study

1. Output measurement of high energies x-photon beams used in radiotherapy treatment
2. Output measurement of electron beams used in radiotherapy treatment
3. Determination of percentage depth dose of high energy photon beams and electron beams
4. Radiation protection survey of teletherapy installations
5. Radiation protection survey of brachytherapy installations
6. Radiation protection survey of diagnostic radiology installations
7. Survey of a radioisotope laboratory and study of surface and air contamination
8. In-phantom dosimetry of a brachytherapy source
9. Preparation and standardization of sealed sources/unsealed sources
10. Study of linearity of dose monitoring system of linear accelerator
11. Brachytherapy treatment planning procedures using a computerised radiotherapy treatment planning system
12. Teletherapy treatment planning procedures using a computerised radiotherapy treatment planning system
13. Measurement of symmetry and flatness of therapy beam using Radiation field analyser (RFA)
14. Percentage depth dose and penumbra measurement of therapy beam using Radiation field analyser (RFA)
15. TMR measurement using radiation field analyser(RFA)
16. Quality assurance test procedures of brachytherapy machine
17. Quality assurance test procedures of teletherapy machines
18. Quality assurance of diagnostic x-ray machine
19. Acceptance and commissioning protocol of radiotherapy equipments
20. Layout preparation and building Planning procedures of radiotherapy installations
21. Contamination check of teletherapy machine
22. Contamination check of brachytherapy source
23. National Regulatory requirements for radiation facility in medical institution