Bharathiar University, Coimbatore – 641 046
Department of Medical Physics

VISION

To produce professionally competent Medical Physicists and qualified Radiation Safety Officers (RSO) to the nation through effective teaching along with clinical exposure and translational research programs.

MISSION

The mission of the department is to

- ✓ Train medical physics professionals to ensure utmost quality patient care.
- ✓ Provide excellent learning opportunities and educate in a variety of Medical Physics oriented disciplines includingradiology, radiation oncology, nuclear medicine and radiobiology. Provide sound understanding that would be the best starting point for advances in medical physics and related technology.
- ✓ Provide outstanding training in Medical Physics service for the safe and effective delivery of cutting edge radiotherapy treatments and medical imaging.
- ✓ Our research mission is to develop better methods and technologies for the personalized diagnosis and treatment of cancer disease focusing on radiation based approaches in medical imaging, radiation oncology, and image guided intervention

Programme Objectives (PO) for M.Sc. Medical Physics

On completion of M.Sc., Medical Physics, the students are expected to

PO1: Possess knowledge on ionizing and non-ionizing radiation, comment on interaction of ionizing radiation with matter.

PO2: Demonstrate the working knowledge of radiation detection, protection, instrumentation and biological effects of radiation.

PO3: Exhibit skills in handling GM counters, Gamma ray spectrometer, analyze the sources, determine linear and mass attenuation of sources, optically stimulated luminescence dosimetry, Treatment Planning System, LINAC, optical microscope, class II bio safety cabinet, CO_2 incubator and QA tools.

PO4: Have domain knowledge in electronic components, computing skills using MATLAB, MATHEMATICA, STATISTICA and analyze the results obtained in radioactive counting, medical imaging or therapy.

PO5: Learning step by step quality assurance/quality control procedures in medical imaging equipment and radiation therapy.

PO6: Categorize proper application of dosimetry and its instruments in medical imaging, radiation treatment or radiation dose delivery.

PO7: Gain skills on clinical aspects of radiation oncology with necessary knowledge in anatomy, pathology, site specific signs, symptoms, diagnosis and management.

PO8: Understand the issues of managing a safety programme as mentioned by regulatory bodies including legal aspects, ethical and cultural aspects.

PO9: Distinguish imaging techniques based on the demonstration of live blood perfusion imaging in nuclear medicine through PET-CT, SPECT and Gamma Camera.

PO10: The applicators insertion of radioactive implants directly into the tissue during appropriate brachytherapy treatment for cervical cancer and prostate cancer.

PO11: Show readiness with comprehended knowledge of emergency response required for the industry, medical appliances, licensees, inspection, and enforcement.

PO12: Awareness of radiation safety and protection standards at national and international level.

Programme Educational Objectives (PEO)

Post graduates of Medical Physics (M.Sc.) course will be

PEO1: Disseminating their knowledge acquired through the state-of-the art radio therapeutic techniques and medical imaging for providing and ensuring safety treatment for the needy human.

PEO2: Imparting their expertise earned through experiential learning towards the effective treatment of cancer patients with a team work and leadership skill to excel in their profession.

PEO3: As medical physicist/radiation safety officers they could achieve continuous improvement in their professional career and advanced technologies in health care through lifelong learning, appreciating human values with professional ethics.

BHARATHIAR UNIVERSITY, COIMBATORE-46

M. Sc. Medical Physics (Univ. Dept.)

For the students admitted during the academic year 2018 – 2019 onwards

Scheme of Examination

Study Components		Course Title	Subject Code No.	Exam		
				CIA @	Unit. Exam	Total
Semester I	Paper 1	Atomic and Nuclear Physics	13A	25	75	100
	Paper 2	Radiation Physics	13B	25	75	100
	Paper 3	Electronics and Beam Generators	13C	25	75	100
	Paper 4	Solid State Physics	13D	25	75	100
	Paper 5	Applied Anatomy and Physiology	13E	25	75	100
	Practical	Electronics and Radiation Physics Lab	13P	25	75	100
Semester II	Paper 6	Statistical and Numerical Methods	23A	25	75	100
	Paper 7	Radiation Detectors and Instrumentation	23B	25	75	100
	Paper 8	Medical Imaging Technology	23C	25	75	100
	Paper 9	External Beam Radiation Therapy	23D	25	75	100
	Paper 10	Radiation Dosimetry and Standardization	23E	25	75	100
	Practical	Medical Physics Lab I	23P	50	100	150
		Summer training				
Semester III	Paper 11	Brachytherapy and Computers in Treatment Planning	33A	25	75	100
	Paper 12	Radiation Biology	33B	25	75	100
	Paper 13	Nuclear Medicine and Internal Dosimetry	33C	25	75	100
	Paper 14	Radiation Hazards Evaluation and Control	33D	75	75	150
	Paper 15	Recent Advances in Radiotherapy	33E	25	75	100
Sem IV	Practical	Medical Physics Lab II	43P	50	100	150
	Project	Project Work (45-60 days) and Viva Voce	43V	300	-	300
Total						2250

CIA split-up:

For all theory papers except RHEC: 10(class test) + 5(viva) + 5(Sem.) +5(Assign.)

For RHEC: 30(class test) + 15(int.1 viva) + 15(int. 2 viva) +10(Sem.)+5(Assign.)

For Practical: 25 (int. 1) + 25 (int. 2)

For Project: 100(project report) + 75(int. viva) + 50 (ext. guide)

Paper - 1

Title of the Subject : **Atomic and Nuclear Physics** Marks :**100**

Code No. :**13A** No. of Teaching hours:**60**

Course Objectives

- To understand and study the physics of various atomic models and their relative merits/demerits in explaining the properties of matter.
- To understand the physics of absorption and emission spectra of alkali metals along with the theory to understand the hyperfine structure of spectral lines.
- To study the structure and properties of nucleus and evolution of understand the development of nuclear models.
- To study radioactive disintegration and the emergence of Alpha and Beta rays. To study the theories of radioactivity and nuclear fission.
- To understand various types of natural/particle induced nuclear reactions.

Unit 1: Atomic structure of Matter

Thomson, Rutherford Model – Bohr' Theory - Bohr's theory of Hydrogen atom – Drawbacks of these models – Bohr's correspondence principle – Sommerfeld's extension to Bohr model – Frank and Hertz experiment – Types of spectra - Emission and absorption line spectra – Fluorescence and Phosphorescence – Characteristics of vector atom model – Related Problems

Unit 2: Alkali spectra, space Quantization and Periodicity

Angular and magnetic momenta – Orbital angular momentum – Electron spin and quantum number – Total angular momentum and magnetic moment of electron – Magnetic quantum numbers – Spin Orbit interaction - LS Coupling Scheme – Selection rules – Pauli exclusion principle – Electron configuration of atom – Periodic Table - Zeeman effect – Lande's –g – factor- Paschen Back effect – Stark effect – Stern Gerlach Experiment – Hyperfine structure of spectral lines

Unit 3: Nuclear force and Binding

Properties of Nuclear Force – Ground state properties of Deuteron – Square well solution of Deuteron – Low energy neutron proton scattering - Limits of energy for the scattering of different partial waves - Binding energy - Weizacker's semi empirical mass formula – Application of semi empirical formula for alpha decay – mass parabola for stability of nuclei against beta decay - Evidence of shell effects – Single particle energy levels for infinite square well, harmonic oscillator with spin orbit potential – Application of shell model for spin and parity

Unit 4: Radioactive disintegration

Properties of radioactive rays – Law of radioactivity – Radioactive equilibrium - Radioactive series - Range of alpha particles – Alpha spectrum and Fine structure - Alpha-Particle Disintegration Energy- Gamow's theory of Alpha decay – Energetics of Beta decay - Beta-Ray Spectra- Pauli's neutrino hypothesis – Properties of neutrino - Gamma emission – Selection rules – internal conversion - Fission process on the basis of liquid drop model - Nuclear fission energetics - Stability limits against spontaneous fission – Potential for fission - Bohr-Wheeler model -

Unit 5: Nuclear reactions

Types of nuclear reaction – Conservation laws in nuclear reactions – Balance of Mass and Energy in nuclear reactions – The Q equation and its solution – Proton, deuteron, neutron and alpha induced reactions – Cross section of nuclear reactions - Separation of center of mass motion in two body problem – Partial wave method for scattering and reaction cross section – Compound nucleus hypothesis – Breit Wigner one level formula.

Reference Books

1. Nuclear Physics: An Introduction, S. B. Patel, New Age International, New Delhi, 2nd edition, (2011).
2. Nuclear Physics S. N. Ghoshal, S. Chand, 1st edition (1997).
3. Introductory Nuclear Physics, K. S. Krane, & D. Halliday, John Wiley & Sons, New York, 1st edition (2008)
4. Nuclear Physics D. C. Tayal, Himalaya Publishing House, 2nd edition, (2009).
5. Modern Physics, S. L. Kakani, & S. Kakani, Viva Publications, New Delhi, 2nd edition, (2006).

Course Outcomes

On successful completion of the course, the students will be able to

CO1 - know about various atomic models

CO2 - explain the origin of spectral lines and hyperfine splitting due to electric and magnetic fields through quantum theory.

CO3 - understand the nature of nuclear forces and the application of shell model to explain spin and parity.

CO4 - understand the physics of radioactive disintegration and emission of Alpha and Beta rays. To explain the fission and fusion process based on suitable nuclear models.

CO5 - solve problems related with particle induced and natural nuclear reactions.

Course prepared by: **Dr. S. VIJAYAKUMAR**

Assistant Professor,
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Course verified by: **Prof. Dr. P. CHRISTOPHER SELVIN**

Head of the Department i/c,
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Paper – 2

Title of the subject : **RADIATION PHYSICS** Marks:**100**

Code Number : **13B** No. of Teaching hours:**60**

Course Objectives

The learning objectives of this course is to understand

- Radiation sources, types and its properties
- Production and properties of X-rays
- Radiation Quantities and Units used in the industry
- Interaction of indirectly ionizing radiation with matter and its effects
- Interaction of directly ionizing radiation with matter and its effects

Unit I: Ionizing radiation and Radiation Sources

Electromagnetic spectrum – Classification - Different sources of Non Ionizing radiation. Radiofrequency, Microwaves, Infrared, Visible and Ultra violet radiation production, physical properties and their interaction with tissues- Sources of ionizing radiation, properties, shielding materials and medical applications.

Radiation sources: Natural and artificial radioactive sources – Large scale production of isotopes – Reactor produced isotopes – Cyclotron produced isotopes – Fission products – industrial uses– Description of radium and radium substitutes- Construction, production, properties and decay scheme of Tele therapy sources-37,Cs,60Co, 192Ir, 125I and other commonly used brachytherapy sources– Gold seeds – Tantalum wire – Beta ray applicators – Thermal and fast neutron sources– Preparation of tracers and labeled compounds – Preparation of ratio colloids.

Unit II: X-ray generator

X-ray generator: Discovery, production, properties of X-rays and X-ray spectra- History of X-ray tubes – Basic requirements of medical diagnostic, therapeutic and industrial radiographic tube – Rotating anode tubes – Hooded anode tubes – Industrial X-ray tubes – X-ray tubes for crystallography – Rating of tubes – Safety devices in X-ray tubes – Ray proof and shockproof tubes – Insulation and cooling of X-ray tubes – Mobile and dental units – Faults in X-ray tubes – Limitations on loading.

Unit III: Radiation Quantities and Units

Radiometry quantities: Particle flux and fluence, Energy flux and fluence, fluence rate, Intensity. Interaction coefficients: Cross section, Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, stopping power, Mass stopping power, LET, Radiation chemical yield and W value. Radioactivity related quantities- activity, specific

activity etc. Dosimetry quantities– Energy imparted, absorbed dose, absorbed dose rate, Exposure, Air kerma rate constant – Charged particle equilibrium (CPE), Relationship between kerma, absorbed dose and exposure under CPE. Radiation protection quantities: Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effected dose, Concepts of collective dose, KERMA, CEMA, Terma, Ambient and directional dose equivalents [(H*(d) andH'(d)], individualdose equivalent penetrating Hp(d), Individual dose equivalent superficial Hs(d).

Unit IV: Interaction of indirectly ionizing radiation with matter

Interaction of photons with matter- Exponential attenuation – Thomson scattering – Photoelectric and Compton process and energy absorption – Pair production – Attenuation and mass energy absorption coefficients – Relative importance of various processes. Neutron classification, neutron sources, Interaction of neutrons with matter- Scattering, absorption – Capture- Neutron induced nuclear reaction- radioactive capture reaction (n, p), (n, r) etc- moderation- shielding materials.

Unit V: Interaction of directly ionizing radiation with matter

Interaction of charged particles with matter – 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 – Radioactive collision – Bremmstrahlung – Energy transfer mechanism, Bragg curve, Bethe Bloch Formula, Passage of heavy charged particles through matter, specific ionization. Buildup correction, shielding materials- Energy loss by collision- Range energy relation- 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.

Reference Books

1. Radiation Physics in Radiology, Oliver R., Blackwell Science Ltd; 1st edition (1966).
2. Radiation Physics for Medical Physicists,E.B.Podgarsak,Springer Verlag, 1st edition (1996).
3. The Physics of radiology, H.E.Johns and Cunningham, Charles C Thomas Publishers, 1st edition (1984).
4. Radiation Oncology Physics: Handbook for Teachers and Students, E.B.Podgarsak, IAEA, Vienna, 1st edition (2005).
5. Introduction to Radiological Physics and Radiation Dosimetry, F.H. Attix, Viley–VCH, Verlog, 1st edition (2004).
6. Christensen's introduction to the Physics of diagnostic radiology,Curry,T.S.Dowdey and J.E. Murry,R.C , Philadelphia, Lea &Febiger , 4th edition (2005).

7. X-ray equipment for student radiographers, Chesney, D.N. &Chesney,M.O, Blackwell Scientific Publications; Oxford (UK), 3rd edition (1984).

Course Outcomes

On successful completion of the course, the students will be able to

CO1 - Explain different types of Radiation, and their sources/properties.

CO2 - Understand how X-rays are produced and their use in various industries.

CO3 - Radiation Quantities and Units.

CO4 - Physics aspects of Interaction of indirectly ionizing radiation with matter.

CO5 - Interaction of directly ionizing radiation with matter and its effects inside a living object.

Course prepared by: **Dr. S. HARIKRISHNA ETTI**

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Paper – 3

Title of the Subject : **Electronics and Beam Generators** Marks :**100**

Code No. : **13C** No. of Teaching hours: **60**

Course Objectives

- To study the working principle of various types of diodes and transistors and their applications in electronic devices. To learn the application of Op-amps for various mathematical applications.
- To gain knowledge in the fundamentals of digital principles and its applications.
- To understand the working of flip flops and construction of registers/counters.
- To learn about 8085 microprocessor and using it for various programming applications.
- To understand the working principle of electronic circuits for the generation of X-rays.

Unit I: Analog Electronics

Semiconductors, Bonds in semiconductor, Energy band description of semi conductor, Classification of semiconductors, hole and electron concentration, Zener diode- characteristics - voltage regulator circuits - Bipolar junction transistors - CB and CE configuration characteristics. FET, MOSFET-principle of operation- characteristics, Op-Amp-circuit symbol-ideal Op-Amp-characteristics- CMRR- Applications: Adder, Subtractor, Analog integrator, Analog differentiator, Voltage-to-current converter, Current-to-voltage converter and Logarithmic amplifier.

Unit II: Digital Electronics I

Logic gates - Boolean algebra - Boolean laws – De-Morgans theorem -Implementation of logic circuits from truth table – Sum-of-Products method – Products-of-Sum method – Multiplexer and de-multiplexer circuits - BCD to Decimal decoders - Seven segment decoders - Decimal to BCD encoder - Half-adder and Full-adder

Unit III: Digital electronics II

Types of Flip Flops: RS, Clocked RS, D-Flip Flop, Edge-triggered D Flip flop – J K Flip flop - Master slave JK Flip flop - Sequential logic circuits: Types of registers– Serial in - Serial out – Serial in – Parallel out – Parallel in Serial out – Parallel in Parallel out registers – Applications - Counters: Ripple counters - up, down and up-down ripple counters - Asynchronous and synchronous counters. A/D and D/A converters.

Unit IV: Microprocessors and Computer programming in C

8085A- architecture and pin configuration - basic 8085 instructions – assembly language programming.

Constants – Varibles – Data types – operators and Expression – Input – output statements – control statements functions – arrays – one, two, multidimensional array declarations and initializations – simple applications.

Unit V: X-ray generator circuits

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.

Reference Books

1. A text book of Electronics, Santanue Chattopadhyay, New Central Book Agency, Kolkata, (2006).
2. Digital Principles and Applications, A.P. Malvino and D.P. Leach, Tata McGraw-Hill Publishing Co, New Delhi, 1st edition (1996).
3. Electronic Principles and Applications, A.B. Bhattacharya, New Central Book Agency, Kolkata, 1st edition (2007).
4. Christensen's Introduction to the Physics of diagnostic radiology, Curry,T.S.Dowdey and J.E. Murry,R.C, Philadelphia,Lea&Febiger, 4th edition (2005).
5. Introduction to Microprocessors,A.P. Mathur, Tata McGraw-Hill Publishing Co, New Delhi,1st edition (2005).
6. Programming in C, S.G. Kochan, CBS Publishers & Distributors, Delhi, 1st edition (1991).

Course Outcomes

On successful completion of the course, the students will be able to

CO1 - understand the usage of various semiconductor based components/devices for constructing electronic circuits.

CO2 - use various logic gates and learn the fundamentals of digital electronics.

CO3 - know how the digital data is stored and shifted in CPU using shifters and counters.

CO4 - understand the basics of 8085 Microprocessor and able to write/execute the C programming for application purpose.

CO5 - use and control X-ray generators for therapeutic applications.

Course prepared by: **Dr. S. VIJAYAKUMAR**
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Paper – 4

Title of the subject : **SOLID STATE PHYSICS** Marks:**100**

Code number :**13D** No. of Teaching hours: **60**

Course Objectives

The learning objectives of this course is to understand

- Crystalline state and structures
- Thermal and Dielectric properties of solids
- Magnetic Properties of Materials
- Superconductivity and Semiconducting properties of solids
- Optical Properties of solids

Unit I: Crystal structure

Crystalline state- Basic definitions- Lattice and Basis-Lattice translational vector Primitive cells and unit cells – Wigner –Seitz cell – Indexing of planes, directions and positions of atoms-crystal systems – Bravais lattices - Simple crystal structures (Hexagonal close packed structure, NaCl, CsCl, Diamond structure, Cubic ZnS structure) X-ray diffraction – Laue's Treatment-Braggs treatment – Laue's method-Rotating crystal method-Powder method.

Unit II: Thermal and Dielectric properties of solids

Dulong-Petitslaw – Einstein theory of specific heat – thermal conductivity – factors affecting thermal conductivity Basic definitions - Local field – ClausiusMossotti relation – Electronic, Ionic, orientational and total polarizability – measurement of Dielectric constants and its measurements Ferro electricity – Electrets – Hysteresis-Piezoelectricity - Applications.

Unit III: Magnetic Properties of Materials

Terms and definitions used in magnetism – Classification of magnetic materials – Langevin theory of diamagnetism – Langevin theory of paramagnetism - Quantum theory of paramagnetism – Ferromagnetism – Spontaneous magnetization in ferromagnetic materials – Hysteresis curve of ferromagnetic materials – origin of Ferromagnetic domains – Bloch wall - Antiferromagnetism – Molecular field theory of antiferromagnetism – Ferrimagnetism.

Unit IV: Superconductivity and Semiconducting properties of solids

Definitions: Critical temperature– critical magnetic field – Critical current – Persistent current - The Meissner effect – Type 1 and 2 superconductors – Intermediate state – Vortex state - London equations –BCS theory –DC and AC Josephesen effect - Applications.

Semiconductors - Direct and indirect band gaps – Classification of semiconductors – Concentration of electrons in the conduction band – hole concentration in the valence band – Electrical conductivity in semiconductors.

Unit V: Optical Properties

Absorption processes- Photoconductivity – Photoelectric effect – Photovoltaic effect – Photoluminescence – Thermoluminescence – Fluorescence – Radio luminescence- Phosphorescence Colourcentres – Types of colourcentres – F-Centre - Generation of colourcentres. MASER and LASER

Reference Books

1. Solid State Physics, R.J.Singh, Pearson, 1st edition, (2012).
2. Solid State Physics: Structure and Properties of Materials, A.M.Wahab, Narosa Publishing house, New Delhi, India, 2nd edition (2007).
3. Elementary Solid State Physics: Principles and Applications, M.A.Omar, Pearson Education Pvt. Ltd., Delhi, India, 4th edition (2004).
4. Introduction to Solid State Physics, C. Kittel, John –Wiley & Sons (Asia) Pvt Ltd., New Delhi, 7th edition (1996).

Course Outcomes

At the end of Solid State Physics course, students should have learnt the basic physics of:

CO1 - Crystals structures of solids used in medical equipment's

CO2 -Thermal and Dielectric properties of solids and their applications in medical and other industries.

CO3 - Magnetic Properties of Materials which is widely used in medical equipments.

CO4 - Superconductivity and Semiconducting properties of solids used in relays and switches in the machines.

CO5 - Various Optical Properties exhibited by solids like laser, which an alternative tool in diagnostic radiology.

Course prepared by: **Dr. S. HARIKRISHNA ETTI**

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Paper – 5

Title of the Subject : **Applied Anatomy and Physiology** Marks: **100**

Code No. : **13E** No. of Teaching hours: **60**

Course Objectives

- To study skin, Lymphatic, Bone and muscular systems. To learn about nerves, endocrine, cardiovascular, respiratory and digestive systems.
- To identify different organs/structures on plain X-rays, CT-scan and other available imaging modalities. To distinguish normal anatomy from abnormalities and understand tumour pathology and carcinogenesis.
- To know the importance of Radiation therapy, Surgery, Chemotherapy and Harmone therapy. To understand the basis of immunotherapy and radionuclide therapy for benign and malignant disease.
- To identify site specific symptoms in Head and Neck, Breast, Gynecological and Gastro-Intestinal tract.
- To recall principles of professional practice and medical terminology. To understand ethical and cultural issues, legal aspects and confidentiality.

Unit I: Structure & function of organs, systems & their common diseases

Skin, Lymphatic system, Bone and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and ear.

Unit II: Basic, Radiographic anatomy and tumor pathology

Anatomy of human body, nomenclature & 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 & deviation for abnormalities. Tumor pathology and carcinogenesis, common pathological features of cancers and interpretation of clinico-pathological data.

Unit III: Clinical aspects of Radiation Oncology

Radiation therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy & Radionuclide therapy, Benign and malignant disease, Methods of spread of malignant disease, Staging and grading systems, Treatment intent – Curative & Palliative, Cancer prevention and public education and Early detection & Screening. Patient management on treatment – side effects related to radiation and dose – Acute & Late – Monitoring and common management of side effects – Information and communication.

Unit IV: Site specific signs, symptoms, diagnosis and management

Head and Neck, Breast, Gynecological, Gastro-Intestinal tract, Genito-Urinary, Lung &

Thorax, Lymphomas & Leukemias & Other cancers including AIDS related cancers.

Unit V: Professional aspects and role of medical physicists

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

Reference Books

1. Normal Radiation Anatomy, Meschan, WB Sunders Company, 8th edition, (1969).
2. Hollinshead Text Book of Anatomy, Cornelius Rosse, LWW, 5th edition, (1997).
3. Anatomy and Physiology, Rod R. Seely, Mcgraw-Hill College , 5th edition, (1999).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - familiar with structure and function of Organs, systems etc..,

CO 2 - recollect common pathology features of cancers and interpretation of clinico-pathological data.

CO 3 - understand cancer prevention and public education and early detection and screening.

CO 4 - recollect professional aspects and role of Medical Physicists.

CO 5 - know the management of side effects related to radiation and dose.

Course prepared by: **Dr. M. Nagarajan M.D,**
Head-Radiation Oncology,
VNCC,
GKNM Hospital, Coimbatore.

Course verified by: **Prof. Dr. P. CHRISTOPHER SELVIN**
Head of the Department i/c,
Department of Medical Physics,
Bharathiar University, Coimbatore – 641046.

Title of the Subject :**Electronics and Radiation Physics Lab** Marks : **100**

Code No. : **13P** No. of Teaching hours : **70**

Objectives

- To get hands-on- experience on the usage of BJT and FET for constructing an amplifier.
- To know the characteristics and applications of operational amplifier for carrying out mathematical operations.
- To use C, MATLAB, MATHEMATICA, STATISTICA programs for graphical representation of medical imaging/report of cancer patients.
- To get hands-on experience to monitor background radiation and find the hidden source.
- To understand the basic laws in Radiation Physics like Inverse Square Law and performance of in-vitro/in-vivo dosimetry. To detect ionizing radiation using various radiation detectors.

List of Experiments (Any 15 experiments)

1. Zener regulated power supply and percentage of regulation.
2. Transistor characteristics- CB configuration.
3. Transistor characteristics- CE configuration.
4. Single stage R-C coupled transistor amplifier.
5. FET characteristics.
6. Single stage FET amplifier- CS configuration.
7. OP-Amp applications- Adder, Subtractor, Differentiator and Integrator.
8. Logic gates OR, AND, NOT, NOR and NAND Gates.
9. NAND gate as a universal gate.
10. Half adder and Full adder.
11. A/D and D/A converters.
12. Programs using C
13. Programs using MATLAB.
14. Programs using MATHEMATICA.
15. Programs using STATISTICA.
16. Characterization of Photosensitive diodes and heel effect.
17. Statistics of Radioactive Counting
18. Determination of plateau and revolving time of a G.M. counter and its application in estimating the shelf-ratio and activity of a beta sources.
19. Calibration of gamma ray spectrometer and identification of unknown sources.
20. Find the detection efficiency of GM counters for both Gamma and beta emitting Sources.
21. Determination of Linear and Mass attenuation coefficients for Al, Cu and Pb.
22. Spectral analysis of Cs source using Gamma ray spectrometer
23. Attenuation of X/Gamma rays through different materials and HVL analysis.

Reference Books

(1) Practical Electronics: Components and Techniques, J. Hughes, O'Reilly Media, 1st edition, (2015).
(2) Practical Electronics Handbook, Ian Sinclair, Elsevier 6th edition, (1980).
(3) Introduction to Radiological Physics and Radiation Dosimetry, Frank H. Attix, John wiley& sons, 1st edition (1986).

Practical Outcomes

On successful completion of the course, students will be:

1. Capable of constructing regulated power supply and amplifiers using BJT. Use FET for constructing amplifiers.
2. Able to construct adder, subtractor, differentiator and integrator using Op-Amp.
3. Capable of writing/executing programs using C, MATLAB, MATHEMATICA and STATISTICA.
4. Aware of the background radiation level.
5. Familiarized with the radiation based instruments. Perform in-vivo dosimetry on cancer patients to assure the dose delivered. Handle radiation detectors during the quality assurance programme.

Course prepared by: **Dr. C.S. Sureka, Dr. S. Vijaya Kumar,**
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Course verified by: **Prof. Dr. P. CHRISTOPHER SELVIN**
Head of the Department i/c,
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Paper – 6

Title of the Subject : **Statistical and Numerical Methods** Marks:**100**

Code No. : **23A** No. of Teaching Hours:**60**

Course Objectives

- To study the concept of probability and distribution functions.
- To understand and study the methods of counting and their usage in medical fields.
- To study about solving various algebraic, transcendental and simultaneous equations using numerical methods.
- To derive appropriate numerical methods to solve curve fitting, integration and Monte Carlo methods
- To study about various numerical methods to solve the ordinary and partial differential equations.

Unit 1: Probability, Statistics and Errors

Addition and multiplication laws of probability, conditional probability, population, variants, collection, tabulation and graphical representation of data -Frequency distributions, Measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, General limitation of an average, dispersion, standard deviation, coefficient of variation, properties of standard deviation, merits and limitation of standard deviation, variance, moments, skewness and kurtosis - Binomial, Poisson, Gaussian distributions – Correlation and Regression, Chi-Square distribution

Unit 2: Counting and medical statistics

Statistics of nuclear counting - Application of Poisson's statistics – Goodness-of-fit tests – lexie`s divergence coefficients - Statistical aspects of gamma ray and beta ray counting – Special consideration 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 Application to radiation detection – uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit.

Unit 3: Roots of equation and Interpolation

Bisection – False position method – Newton Raphson method – Gauss elimination method - Gauss Jacobi method – Gauss Seidal method – Inversion of a matrix using Gauss elimination method - LU decomposition - Gregory Newton's forward and backward difference

formula for equal intervals – Divided difference – Properties of divided difference – Newton's divided difference formula – Lagranges interpolation formula for unequal intervals

Unit 4: Curve fitting, integration, and montecarlo methods

Method of least squares – straight line, parabola, Newton-Cotes method - Trapezoidal rule, Simpson's $1/3^{rd}$ rule-Simpson's Three-Eight rule, Boole rule, Weddle rule. Monte Carlo Method vs Deterministics Method - Generation of random numbers- Test for randomness- Discrete and continuous Random variables- Solving simple integrals using different Monte Carlo techniques - law of large numbers - the central limit theorem - variance reduction techniques.

Unit 5: Ordinary and partial differential equation

Ordinary differential equation– Taylor series method – Basic, Improved and Modified Euler methods – RungeKutta IV order method for first order differential equation – RK4 method for simultaneous first order differential equations – RK4 method for second order differential equation – Milne's Predictor – Corrector method – Partial differential equation – difference – quotients – Graphical representation of partial quotients – Classification of Partial differential equations of the second order – Standard five point formula – Diagonal five-point formula – Solution of Laplace's equation by Liebmann's iteration.

Reference Books

1. Numerical Methods for Engineers and scientists, J. D. Hoffman, Marcel Dekker Inc., New York, 2^{nd} Edition, (2001).
2. Numerical Methods for Engineers and scientists – A students course book A.C. Bajpai, I. M. Calus and J.A. Fairley, John Wiley & Sons, New York 1^{st} edition (1977).
3. Introduction to Mathematical Physics, W. Band, Van Nostrand Reinhold Inc.U.S.,1^{st} edition, (1959).
4. Elementary statistics with applications in medicine and the biological sciences, F. E. Croxton, Dover, New York, 1^{st} edition (1959).
5. Statistical Method of Medical &Biology students, G. Dahlberg, G. Allen & Unwin Ltd, London,2^{nd} edition, (1948).
6. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India, New Delhi, 5^{th} edition, (2012).
7. Numerical Methods wit programs in C, T.Veerarajan& T. Ramachandran, Tata Mcgraw Hill, New Delhi, 2^{nd} edition, (2006).
8. Techniques for Nuclear and Particle Physics Experiments: A How-to Approach, W. R. Leo, Springer Science & Business Media; 2^{nd} edition, (2012).

Course Outcomes

On successful completion of the course, the students will be able to

CO1 - understand the basic concepts of probability, statistics and distribution functions.

CO2 - gain adequate knowledge and working principle of the Gamma ray, Beta ray counting methods and medical statistics.

CO3 - deduce the solution for various algebraic, transcendental and simultaneous equations using different approximation methods.

CO4 - method of solving problems in curve fitting, integration and Monte Carlo methods.

CO5 - enhance the problem solving ability of students in numerical methods using differential equations.

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Paper – 7

Title of the Subject **: Radiation Detectors and Instrumentation** Marks **: 100**

Code No. **: 23B** No. of Teaching hours**: 60**

Course Objectives

- To understand the technical- know- how of all the radiation detectors used for cancer diagnosis, treatment, radiation safety, and in industry.
- To provide a thorough knowledge about the principle of various radiation detectors, monitors and dosimeters.
- To learn about the working of radiation instruments used in advanced radiation therapy.
- To understand the applications and uses of radiation safety devices.
- To understand the various factors behind the measurement of radiation and analysis of data.

Unit 1: Principles of Radiation Detection- Gas filled detectors

Basic Principles of radiation detection– Statistical nature of radiation emission, errors, accuracy and precision of measurements, types of errors- 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 – quenching.

Unit 2: Principles of Radiation Detection- scintillation and other solid state detectors

Scintillation detectors– Different types, the relationship between pulse height and energy and type of incident particle, photomultiplier tube, assembly of a scintillation counter and role of light pipes, dead time of scintillation counters, sources of background in a scintillation counter, resolving time, resolving power- Semiconductor detectors – different types, damage due to radiation- Chemical systems. Radiographic and Radio chromic films – Thermo luminescent Dosimeters (TLD) – Common TLD materials, characteristics, fading, residual TL and annealing for reuse, detection process, glow curve and dose response- Diode detectors- Optically stimulated Luminescence dosimeters (OSLD) – Radiophoto luminescent dosimeters- comparison between all solid state detectors- Neutron Detectors – Nuclear track emulsions for fast neutrons – Solid State Nuclear track (SSNTD) detectors – calorimeters – New Developments.

Unit 3: Dosimetry Instruments

Dosimeters based on condenser chambers – Pocket chambers – Dosimeters based on current measurement – Different types of electrometers – MOSFET, Vibrating condenser and Varactor bridge types – Secondary standard therapy level dosimeters – Farmers Dosimeters – Radiation field analyzer (RFA) – Radioisotope calibrator – Multipurpose dosimeters – Water

phantom dosimetry systems – Brachytherapy dosimeters – Thermo luminescent dosimeter readers for medical applications – Calibration and maintenance of dosimeters.

Unit 4: Radiation Protection instruments

Instruments for personnel monitoring – TLD badge readers – PM film densitometers – Glass dosimeters readers - Digital pocket dosimeters using solid state devices and GM counters – Teledetector – 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 systems.

Unit 5: Nuclear Medicine instruments

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

Reference Book:

1. Nuclear Radiation Detection, William J Price, McGraw-Hill; Ex - Lib 1st edition, (1958).
2. Theory of Luminescence, B. I. Stepanov and V. P. Gribkovskii, Gordon & Breach Publishing Group, 1st edition (1968).
3. Radiation Detection and Measurement, Glenn F. Knoll, Wiley, 4th edition, (2010).
4. Electronics Principles, Albert Paul Malvino Dr., David J. Bates, McGraw-Hill Education; 8th edition, (2015).
5. Electronic Devices and Circuit Theory, Robert L. Boylestad, Pearson, 10th edition, (2009).
6. Art of Electronics, Paul-Horowitz and Winfield Hill, Cambridge University Press; 3rd edition, (2015).
7. Semiconductor devices and applications, Richard Anton Greiner, McGraw-Hill, 1st edition (1961).

Course Outcomes

On successful completion of the course students will be able to:

CO1- Be familiar with an updated fundamental knowledge, technological advancements and potential applications of radiation detectors.

CO2- Gain information on the latest advances in radiation detectors, which is a powerful tool needed for cancer diagnosis, treatment, radiation safety, and in industry.

CO3- Learn about radiation instruments available for research and the scope for further research.

CO4 - Acquire knowledge on radiation safety and personal monitoring devices.

CO5- Measure radiation precisely and interpret their results accurately with statistical significance.

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Paper – 8

Title of the subject : **MEDICAL IMAGING TECHNOLOGY** Marks:**100**

Code Number : **23C** No. of teaching Hours: **60**

Course Objectives

The learning objectives of this course is to understand

- Physical principle and components of Radiography
- Conventional and digital radiography techniques
- Computed Tomography
- Magnetic Resonance Imaging (MRI) and Ultrasound Imaging
- Safety in Diagnostic Radiology

Unit I: Physical principle and components of Radiography

Physical Principle: Interactions of X-rays with human body, differential transmission of X-ray beam, spatial image formation, visualization of spatial image, factors influencing resolution evaluation of resolution - 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. Filters: inherent and added filters, purpose of added filters, beryllium filter, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolinium, molybdenum). Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, contrast reduction factor, scatter reduction methods: beam restrictors (diaphragms, cones/cylinders & collimators), grids (grids function, different types of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique. Intensifying screens: Function of intensifying screens, function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare-earth screens. Radiographic Film: Components of radiographic film, physical principles of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.,).

Unit II: Conventional and digital radiography techniques

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

Mammography and fluoroscopy: AEC. Compression Paddle, HVL- Modern tends in interventional Radiology- Bi- Plane imaging, rotational angiography, cardiac imaging real time imaging characteristics – continuous and pulsed fluoroscopy, high dose rate fluoroscopy, Dose area product (DAP) meters, peak skin dose, dose management for pediatric and pregnant patient in interventional imaging, Diagnostic Reference Level and guidelines.

Xero-radiography, C- arm, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography and orthopan tomography (OPG) (principle only).

Unit III: Computed Tomography

Conventional X-ray tomography (Basic principle), Data Accumulation, Original EMI Scanner, Scanning motions or Generations- First, Second, Third and fourth Generations, Principle of Helical CT Scan and Scan Parameters (kV, mA.S and pitch)- Other scan configurations-X-ray tubes, Collimators, Detectors-Scintillation crystal and Xenon Gas Ionization chamber, Image reconstruction, Modes of CT acquisition, Axial acquisition, Helical acquisition, Cone beam acquisition, Cardiac CT, CT angiography, CT perfusion – Cone beam reconstruction, Iterative reconstruction, postprocesing tools, volume rendering, SSD, MPR, MIP factor affecting patient dose CTDI, CTDI vol, CTDI w dose length product (DLP), multiple scan average dose (MSAD). Algorithms for Image reconstruction-Back projection, Iterative method and Analytical methods, Comparison of Mathematical models, CT Numbers, Image display, Image quality, Resolution-Spatial and contrast resolution, Patient exposure, Artifacts-Motion artefacts, Streak artefacts, Beam hardening artefacts and Ring artefacts, 3D Imaging –Surface reconstruction and Volumetric reconstruction.

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

Magnetic Resonance image – Hydrogen characteristics, magnetization vector, Precession, flip angle. proton density, relaxation time T1 & T2 images – Comparison of T1 and T2- image characteristics – MRI system components – Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, MR signal localization, composite signal, K-space – Basic MR imaging sequences, MR instrument and bio safety, image quality- MRI safety. Interaction of sound waves with body tissues, production of ultrasound – Transducer array – Beam Properties – Near field-far side lobes-spatial resolution. Image data acquisition –data acquisition system, ADC- receiver, Echo display modes, scan converter. Image data acquisition, pulse echo acquisition – ultrasound image display, amplitude mode, Motion mode, brightness mode- ultrasound image quality – image artifacts – Bio effects of ultrasound- colour Doppler.

Unit V: Safety in Diagnostic Radiology

General considerations in design of diagnostic installations- QA of conventional diagnostic X- ray equipment: purpose of QA, QA Protocols, QA Test methods for performance evaluation of diagnostic equipments – Collimator congruence test; accuracy of kVp; HVL, accuracy of mAs; consistency of output; accuracy of mA; small and large Focal Sport size evaluation, radiation safety survey conventional and interventional radiographic systems, phantom test in digital radiography. QA in CT. Other related quality assurance as per the guidelines of the AERB as part of regulation. QA in mammography using phantoms. Performance testing and quality assurance in ultrasound and MRI using accredited phantoms.

Reference Books

1. Christensen's introduction to thephysics of diagnostic radiology, Curry, T.S., Dowdey, J.E., Murry, R.C., Philadelphia: Lea &Febiger, 4th edition, (1990).
2. The essential physics of medical imaging, Bushberg, S.T., Seibert, J.A, Leidholt, E.M.& Boone, J.M., Baltimore: Williams & Wilkins 1st edition (1990).
3. Physics for diagnostic radiology, Dendy, P.P.&B. Heaton, Bristol &Philadelphia: Institute of Physics Publishing, 2nd edition (1994).
4. The physics of radiology, Johns, H.E. & Cunningham, J.R., IL: Charles C. Thomas,Springfield, 4th edition (1983).
5. X-ray imaging equipment, An introduction, E. Seeram, Charles C Thomas Pub Ltd, 1st edition (1985).
6. Medical Imaging Physics,Hendee, W.R.&Ritenour, R, St. Louis: C.V. Mosbey, 3rdedition,(1983).
7. X-ray equipment for student radiographers, Chesney, D.N. & Chesney, M.O., New Delhi: CBS Publishers & Distributors, 3rd edition (2005).
8. Radiographic Imaging, Chesney, D.N.&Chesney, M.O., New Delhi: CBS Publishers & Distributors, 4th edition (2005).
9. MRI: The Basics, Ray HashmanHashemi, William G. Bradley Jr., Christopher J. Lisanti, Lippincott Williams & Wilkins, 1st edition (2004).
10. Magnetic resonance imaging principles, methods and techniques, Sprawls, P., Perry Sprawls, 1st edition (2000).

Course Outcomes

At the end of Medical Imaging Technology course, students should have learned:

CO1 - Physics principles behind the working of components used in Radiography industry

CO2- Conventional and digital radiography techniques and its basics

CO3 - The physics and working of Computed Tomography

CO4 - The basic principles and working of Magnetic Resonance Imaging (MRI) and Ultrasound Imaging

CO5 - Quality assurance methods followed for radiation equipment's as per the national and international guidelines in Diagnostic Radiology

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Paper – 9

Title of the Subject : **External Beam Radiation Therapy** Marks:**100**

Code No. : **23D** No. of Teaching hours:**60**

Course Objectives

- To applying knowledge of treatment parameters like Percentage Death Dose, Tissue Phantom Ratios for computing treatment time calculation required for treatment of radiotherapy patients.To check the dosimetry parameter of treatment machines for using dosimetry tools like RFA, phantoms and etc.
- To be able to constant beam modifying devices for delivering dose effectively.
- To use parameters like treated volume, irradiated volume, hot spot, maximum target dose in choosing a better treatment plan. To adopt and apply 2 D and 3 D simulation techniques CT, MRI, US and PET fusion techniques
- To recognize the need and ability to select proper electron energy for tumors at different depth.
- To understand the merits of electron, neutron an X-ray and Gamma ray beams and heavy charged particles and use them prudently for different types of tumors.

Unit I: Beam generators

Kilo voltage therapy X-ray Units: principle and application of Grenz ray therapy - contact therapy, superficial therapy, orthovoltage, deep therapy.

Telecobalt units: Construction and working, source design, beam shutter mechanisms, mercury shutter pneumatic pressure system, rotating wheel shutter system, beam collimation, penumbra and it's types, trimmers and breast cones, isocentric gantry.

Particle accelerators: Particle accelerators for industrial, medical and research applications - The Resonant transformer – Cascade generator – Van De Graff Generator – pelletron – Cyclotron – Betatron - Synchro – Cyclotron – Microtron - Electron Synchrotron – Proton synchrotron. Linear accelerator- Details of accelerators facilities in India, Construction and working, klystron and magnetron, traveling and standing waveguide, pulse modulators and auxiliary systems, bending magnet systems, treatment beam production - X-rays - electron beam, beam collimation, asymmetric collimator, multileaf collimator, dose monitoring and beam stabilization - electron contamination- relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams.

Unit II: Dosimetry parameters

Central axis dosimetry parameters: 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 – scatter air ratio(SAR) – scatter maximum ratio(SMR)- off axis ratio field factors- surface dose and buildup region- Tissue equivalent phantoms- Radiation Field Analyzer (RFA)- Description and measurement of isodose curves/ charts- Dosimetry data resources.

Unit III: Beam modifiers and treatment planning

Beam modifying and shaping devices – Block Cutting machines- wedge filters – universal, motorized and dynamic wedges - treatment planning with wedges– shielding blocks - field shaping, custom blocking - tissue compensation – design of compensators, 2D compensators, 3D compensators-special considerations in treatment planning - skin dose, field matching, integral dose, DVHs – differential, integral. Treatment planning in teletherepy – target volume definition and dose prescription criteria – Gross tumor volume (GTV), Clinical target volume (CTV), Internal target volume (ITV), Internal margin, Planning target volume (PTV), Organ at Risk (OAR), Treated volume, Irradiated volume, Maximum target dose, Median target dose, Modal target dose and hot spot. ICRU 50, ICRU 62 and ICRU 83- SSD and SAD set ups – two and three dimensional localization techniques, dose specification and normalization- Positioning/immobilization - 2D and 3D simulation techniques- conventional simulator- CT simulator- use of contrast, markers - patient data acquisition- contours, contouring images from CR, CT, MRI, US, PET, fusion techniques - virtual simulation – digitally reconstructed radiographs(DRR). Field arrangements – single, parallel opposed and multiple fields – corrections for tissue in homogeneity, contour shapes and beam obliquity – integral dose. Arc/rotation therapy and Clarkson technique for irregular fields – mantle and inverted Y Fields. Conventional and conformal radiotherapy. Treatment time and Monitor unit calculations- SSD and SAD/isocentric technique, Co-60 and accelerator calculations.

Unit IV: Physics of electron and particulate beam therapy

Clinical electron beams – energy specification – electron energy selection for patient treatment – depth dose characteristic (Ds, Dx, R100, R50, Rp etc.) – beam flatness and symmetry – penumbra – isodose plots – monitor unit calculations – output factor formalisms – effect of air gap on beam dosimetry – effective SSD. Relative merits of electrons, neutron, x-ray and gamma ray beams and heavily charged particles – Neutron capture therapy and Heavy ion (proton and carbon ion) therapy- physical principle and equipment only.

Unit V: Quality assurance in radiation therapy

Quality assurance in radiation therapy – precision and accuracy in clinical dosimetry - quality assurance protocols for telecobalt, medical linear accelerator and radiotherapy simulators– IEC requirements – acceptance, commissioning and quality control of telecobalt, medical linear accelerator and radiotherapy simulators. Portal and in-vivo dosimetry. Electronic portal imaging devices.

Reference Books

1. Radiotherapy Treatment Planning, Medical Physics Hand Book Series No.7, R.F.Mould, Adam Hilger Ltd.,Bristor, 1st edition (1981).
2. Physics of Electron Beam Therapy, Medical Physics Hand Book Series No.6,S.C.Klevenhagen, Adam Hilger Ltd.,Bristor, 1st edition (1981).
3. Radiation Therapy Planning, G.C.Bentel, Macmillan Publishing Co.,New York, 1st edition (1992).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - Understand the principles behind dosimetry parameters and use them for treatment time calculation

CO 2 – learn advance concepts in image registration, target delineation.

CO 3 – use quality assurance tools effectively

CO 4 - learn treatment planning for inverted Y fields, SSD and SAD techniques.

CO 5 – have a thorough knowledge on quality assurance in radiation therapy.

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Paper – 10

Title of the Subject : **Radiation Dosimetry and Standardization** Marks:**100**

Code No. :**23E** No. of Teaching hours:**60**

Course Objectives

- To know the available standard of dosimetry traceability uncertainty in measurements, charge particle equilibrium. To Learn about free air ion chamber, design of parallel plate (FAIC), measurements of Air kerma / Exposure with effective SSD.
- To understand the measurements of DW for external beams from Co 60 teletherapy machines reference conditions formeasurement. To be able to derive the expression for machine timing error, procedure for evolution of temperature and pressure correction.
- To be able to recall primary standards, secondary of neutron dosimeter. To know different types of neutron survey meters and their calibration.
- To be able to understand standardization of beta emitters and electron capture with proportional GM and Scintillation counters. To learn routine sample measurement with liquid counter and scintillation counting methods for alpha, beta and gamma emitters.
- To study LET, Dose-rate effects and radiation chemistry of water and aqueous solutions. To know the effect of effect of radiation on polymer and their applications in dosimetry.

Unit I: Dosimetry & Standardization of X and Gamma Ray Beam

Standards – Primary and Secondary Standards, Traceability, Uncertainly in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure with effective SSD. 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 – Nx, Nk, ND, air, N_D, w. IAEA TRS277: Various steps to arrive at the expression for Dw starting from Nx. TRS398: ND, w, Q : ND, W : $K_{Q,Q}0$: K_Q, Derivation of an expression for $K_{Q,Q}0$. Calorimetric standards –AAPM TG 51 and other dosimetric protocols- Intercomparison of standard.

Unit II: Measurement of Dw for beams from telecobalt machines and for electrons from linac

Measurement of Dw for External beams from ^{60}Co teletherapy machines: Reference conditions for measurement, Type of ion chambers, phantom, Waterproof sleeve, Derivation of an expression for Machine Timing error, Procedure for evolution of Temperature and pressure correction: Thermometers and pressure gauges. Measurement of temperature and pressure.

Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. Parallel plate, cylindrical and spherical ion chambers, K_{sat}, Two voltage method for continuous and pulsed beams Polarity correction.

Measurement of Dw for high-energy Electrons beams (TRS 381) from Linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, Cross calibration using intermediate beam quality and depth dose characteristics. Quality Audit Programmes in Reference and Non-Reference conditions.

Unit III: Neutron Standards & Dosimetry

Neutron standards – primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulpate 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.

Unit IV: Standardization of Radionuclides

Methods of Measurement of radioactivity – Defined solid angle and 4JI counting – Beta gamma coincidence counting – Standardization of beat 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 for alpha, beta and gamma emitter – Reentrant ionization chamber methods – Methods using (n, ŕ) and (n, p) reactions – Determination of yields of neutron sources – Space integration methods – Solids state detectors.

Unit V: Radiation Chemistry and Chemical Dosimetry

Definition of free radicals and G-Values-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 polymerization, effects of radiation on polymers and their applications in dosimetry – Formation of free radicals in solids and their application in dosimetry- Description of irradiators from dosimetric view point – Dosimetry principles – Definitions of optical density, molar absorption coefficient, Beer – Lamberts law, spectrophotometry – Dose calculations - – Laboratory techniques – Reagents and procedures _ Requirements for an ideal chemical dosimeter – Fricke dosimeter – FBX dosimeter – Free radical dosimeter – Ceric sulphate dosimeter – Other high and low level dosimeters – Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

Reference Books

1. Introduction to Radiological Physics and Radiation Dosimetry, F.H. Attix. Viley - VCH, Verlog, 1st edition (2004).

2. Physics of Electron Beam Therapy, Medical Physics Hand Book Series No.6, S.C.Klevenhagen, Adam Hilger Ltd., Bristol, 1st edition (1981).
3. Medical Radiation Physics, W.R.Hendee, Year Book Medical Publishers Inc., London, 1st edition (1981).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - use IAEA – TRS 277 in clinical procedure.

CO 2 –calibrate photon and Co 60 beams.

CO 3 –measure neutron emitted from medical linear accelerator

CO 4 - know the working of netron survey meters.

C0 5 - familiar with chemical dosimetry and radiation chemistry.

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Title of the Subject :**Medical Physics Lab I** Marks :**100**

Code No. : **23P** No. of Teaching hours : **70**

Objectives

- To determine HVL of Co-60 gamma rays for various materials. To determine attenuation coefficients for various materials.
- To study response of ionization chamber under different voltage conditions.
- To measure and verify PDD, TAR and TMR. To determine wedge and tray factor for various wedges and trays.
- To perform isocenter check. To verify field size with graph sheet.To check dose calculations accuracy and different parameters of TPS.
- To create a plan for single and parallel opposed fields using isodose charts. To perform test for calculating effective SSD for an electron beam.

Suggested New Practicals

(1) Attenuation of Gamma rays through various materials and evaluation of HVL
(2) Study of Voltage-Current Characteristics of a Ion Chamber
(3) Measurement and Verification of PDD, TAR and TMR values
(4) Determination of output of a telecobalt unit - Using TRS 398
(5) Wedge and Tray factor determination
(6) Manual monitor unit calculations of simple and complex treatment plans
(7) Quality Assurance of a Telecobalt unit
(8) Quality Assurance of a Treatment Planning System
(9) Quality Assurance of a Linear Accelerator
(10) Autoradiography test for Brachytherapy source in Remote Afterloader unit
(11) Quality Assurance of a Radiography or CT

Demonstrations

(1) Treatment Planning for External Beam with TPS
(2) Treatment Planning for Brachytherapy with TPS
(3) Demonstration of In-air Scanner

Reference Books

1. The Physics of Radiation Therapy,Faiz M. Khan, Lippincott Williams & Willkins, Philadelphia, 3rd edition, (2003).
2. Advanced Medical Radiation Dosimetry, Govinda Rajan, Prentice hall of India Pvt.Ltd., New Delhi,1stedition (1992).
3. IAEA TRS-398, Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water, 1stedition (2006).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - have thorough knowlege on measurements of factors coverning penetration of X-ray and Gamma ray to various materials.

CO 2 – measure and verify treatment planning parameters.

CO 3 – do quality assurance tests of radiation genearating equipment like linear accelerator.

CO 4 - devise a treatment plan for single and parallel opposed fields.

CO 5 - determine variation SSD with electron energy.

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Paper – 11

Name of the Subject: **Brachytherapy & computers in Treatment Planning**Marks:**100**

Code No. :**33A** No. of Teaching hours: **60**

Course Objectives

- To apply gained knowledge in Surface mould, Intracavitary, Interstitial, Intraluminal and Intraoperative techniques in practice. To be familiar with specification and calibration of brachytherapy sources namely RAKR and AKS-IAEA DECEOC 1274 and ICRU-72 recommendation.
- To study afterloading techniques, merits and demerits of manual and remote afterloading techniques. To be able to recollect AAPM and IEC requirements of remote afterloading brachytherapy equipment's.
- To prepare a brachytherapy treatment plan using CT and MRI images. To learn Acceptance and commissioning Test, Quality Assurance (QA) and Quality Control (QC) of radiotherapy (teletherapy and brachytherapy) treatment planning systems using IAEA TRS 430 and other protocols.
- To compose a treatment plan for prostate cancer using Interstitial implant. To learn new technique like Electronic Brachytherapy including Axxent and Mammosite, etc..,
- To explain scope of computers in Treatment Planning Algorithms. To learn about pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms.

Unit I: Brachytherapy physics and dosimetry

Definition and classification of brachytherapy techniques – surface mould, intracavitary, interstitial, intraluminal and intraoperative techniques. Requirement for brachytherapy sources- Dose rate considerations and classification of brachytherapy techniques – Low dose rate (LDR), medium dose rate (MDR), 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 AKS – IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line source dosimetry formalisms – Sievert Integral – AAPM TG-43/43U1 and other dosimetry formalisms.

Unit II: Afterloading techniques

Afterloading techniques – Advantages and disadvantages of manual and remote afterloading techniques. AAPM and IEC requirements for remote afterloadingbrachytherapy equipment. Acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment. ISO requirements and QA and Standardization of Brachytherapy sources – Apparent activity – Reference Air Kerma Rate – Air Kerma Strength – Standards for

HDR ^{192}Ir and ^{60}CO sources – Standardization of ^{125}I and beta sources – IAEA TECDOC 1274 – room scatter correction. Calibration of protection level instruments and monitors- Integrated brachytherapy unit. Manual pre loading systems: Manual after loading systems - remote after loading systems -source trains (fixed and programmable) - stepping source - different types of applicators (gynecological, esophageal, nasopharyngeal, bronchial) and templates.

Unit III: Treatment planning and quality assurance in brachytherapy

Brachytherapy treatment planning – Radiography, CT, MRI based brachytherapy planning – forward and inverse planning. Networking: DICOM and PACS (in detail)- DICOM image import/export from OT – Record & Verification. Acceptance and commissioning Test, Quality Assurance (QA) and Quality Control (QC) of radiotherapy (teletherapy and brachytherapy) treatment planning systems using IAEA TRS 430 and other protocols.

Unit IV: Advances in Brachytherapy

Brachytherapy treatment for prostate cancer. Ocular brachytherapy using photon and beta sources. Intravascular brachytherapy – classification – sources – dosimetry procedures - AAPM TG 60 protocol. Electronic brachytherapy (Axxent, Mammosite, Etc.)

Unit V: Computers in Treatment Planning

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

Reference Books

1. The Physics of Modern Brachytherapy for Oncology, D. Baltas, L. Sakelliou and N. Zamboglou, Taylor & Francis Group, 1st edition (2007).
2. Principles and Practice of Brachytherapy, Subir Nag, Wiley-Blackwell, 1st edition (1997).
3. Technical Basis of Radiation Therapy Practical Clinical Applications, S.H. Levitt, J.A. Purdy, Springer, 4th edition (2012).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - understand the basic concepts behind Surface mould, Intracavitary Interstitial, Intraluminal and Intraoperative techniques

CO 2 – learn different dosage systems like Paterson parker and Manchester Dosage systems and Specification and calibration of brachytherapy sources.

CO 3 – know Quality Assurance and Standardization of brachytherapy sources.

CO 4 - know the importance of DICOM and PACS in radiotherapy

CO 5- understand the importance of plan optimization techniques like direct aperture, beamlet and simulated annealing.

Course prepared by**: Mr.Selvarajan. P**

Faculty-in-charge

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Paper – 12

Title of the Subject : **Radiation Biology** Marks: **100**

Code No. : **33B** No. of Teaching hours:**60**

Course Objectives

- To study the structure of normal and abnormal cells, organic and inorganic constituents and their metabolic activities.
- Understand the effect of radiation at atomic, molecular, organelle, cellular, tissue and organ level and the possible repair mechanisms.
- Know about the availability, applicability and limitations of various Radiobiological models that can extend the results obtained from animal experiments and experience gathered from radiation accidents.
- To realize the early and late effects of radiation on fetus, individual human beings and our generation too.
- To optimize the Radiotherapy plans on biological aspects in order to enhance clinical outcome.

Unit 1: Cell Biology

Cell Physiology and biochemistry – Structures of the normal- nature of cancer cells- transport of ions through cell membrance- Types of cells and tissue, their structures and functions - Organic constituents of cells – Carbohydrates, fats, proteins and nucleic acids – Enzymes and their functions – Functions of mitochondria, ribosomes, golgi bodies 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.

Unit 2: Interaction of Radiation with Cells

Concepts of micro dosimetry- Direct and indirect 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 – inactivations, Mitotic delay, DNA damage, 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- radio sensitivity protocol of different tissues in human.

Unit 3: Radiobiological models

Cell survival curve parameters – in vitro and in vivo experiments on mammalian cell systems- Model for radiation action – Target theory – Single hit Single target – Single hit Multi target - Single hit and Multi hit target theory– Multi hit Single target – Multi hit Multi target - other theories of cell inactivation- Repair misrepair hypothesis – Dual action hypothesis – Modification of radiation damage – RBE, LET, OER, dose rate, dose fractionation – Oxygen and other chemical sensitizers – Anoxic, hypoxic, base analogs, folic acid, and energy metabolism

inhibitors – Hyperthermic sensitization – Radio-protective agents- effects of UV, microwave and other non-ionizing radiation.

Unit 4: Biological Effects of Radiation

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 50/30 and LD 50/60 dose – Effects of radiation on skin and blood forming organs, blood constituents, embryo, digestive track, endocrine glands, gonads– Sterility and cataract formation – Effects of chronic exposure to radiation – Induction of leukemia – Radiation Carcinogenesis – Risk of carcinogenesis – Animal and human data – Shortening of life span – In-utero exposure.

Genetic effects of radiation – Threshold and linear dose-effects relationship- Factors affecting frequency of radiation induced mutations– first generation effects – Effects due to mutation of recessive and dominant characteristics – Genetic burden – gene controlled hereditary diseases and defects – Spontaneous mutation rate – human data on animals and lower species- Concept of doubling dose and genetic risk estimate.

Unit 5: Biological Basis of Radiotherapy

Physical and biological factors affecting cell survival, tumor regrowth and normal tissue response – Non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle – High LET radiation therapy. Time dose fractionation – Basis for dose fractionation in beam therapy – Concepts for Nominal Standard Dose (NSD), Roentgen equivalent therapy (RET) – Time dose fractionation (TDF) factors and cumulative radiation effects (CRE) – Gap correction, Linear and Linear Quadratic models, TCP and NTCP evaluation- problem of hypoxic compartment and quiescent cells- radiobiology of malignant neoplasm- solution of hypoxic cell sensitizers, hyperthermia, combination of chemotherapy and radiotherapy- chronoradiobiology and its applications to get better cure- problem of tumor regression.

Reference Book:

1. Radiobiology for Radiologists, E. J. Hall, J. B. Lippincott Co., 5th edition, (2000).
2. Radiobiology of Humans and animals, S. P. Yarmonenko, MIR, Publishers, 1st edition (1990).
3. Late biological effects of ionizing radiation: proceedings of the Symposium on the Late Biological Effects of Ionizing Radiation, IAEA, Vienna, 13-17 March (1978).
4. Biological effects of ionising radiation, H. Smith and J. W. Stather, Landolt-Börnstein-Group VIII Advanced Materials and Technologies Volume 4, pp 5-40 (2005).
5. Biological Effects of Ionizing Radiation, Dr. Claus Grupen, Graduate Texts in Physics, pp 212-228 (2010).
6. Dosimetry and Biological Effects of Ionizing Radiation, B. Kanyár and G. J. Köteles, Handbook of Nuclear Chemistry, pp 2211-2257 (2011).

7. Radiation Biology: A handbook for teachers and students, IAEA, TRS 42, 1st edition (2010).

Course Outcomes:

On successful completion of the course students will be able to:

CO1: Understand the structure and behavior of normal and abnormal cells.

CO2: Aware of the effects of radiation and alert others to use radiation with caution.

CO3: Overcome Radiophobia and respect radiation.

CO4: Increase the benefits of radiation towards Radiotherapy by reducing its associated risk.

CO5: Realize the scope for further research in health care to serve human society.

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Paper – 13

Title of the Subject : **Nuclear Medicine and Internal Dosimetry** Marks:**100**

Code No. : **33C** No. of Teaching hours:**60**

Course Objectives

- To study the production of radionuclides used in nuclear medicine and types of production. To learn different types of imaging procedures namely In-vivo and In-vitro studies.
- To understand the importance various imaging instruments and their operating principles and to be familiar with various imaging systems and their limitation.
- To recall different imaging techniques like Two dimensional and Three dimensional techniques. To be able to understand focal plane tomography emission computed tomography,etc.
- To narrate Annihilation Coincidence Detection and PET detector scanner design, data Acquisition for PET. To relate working of Medical cyclotron, radioisotopes produced and their characteristics.
- To state single compartmental model, two compartmental model with back transference and two compartmental model without book transference. To study the importance of MIRD technique for Dose Calculations and CumulativeActivity, Equilibrium Dose Constant,etc.

Unit I: Physics of Nuclear Medicine, In-vivo and In-vitro techniques

Introduction to nuclear Medicine, Unsealed Sources, production of Radionuclide used in Nuclear Medicine; Reactor based Radionuclide, Accelerators based Radionuclide, photonuclear activation, Equations for Radionuclide production, Radionuclide Generators and their operation principles. Various usages of Radiopharmaceuticals.

In-vivo non-imaging procedures: Thyroid Uptake Measurements, Reno gram, Life Span of RBC, Blood Volume studies, life Span of RBC etc. General concept of Radionuclide, imaging and Historical developments. In-vitro Techniques: RIA/IRMA techniques and its principles. Difference between in-vivo and in- vitro dosimetry.

Unit II: Components of radionuclide imaging

Radionuclide Imaging: Other techniques and Instruments; The Rectilinear Scanner and its operational principles, Basic Principles and Design of the Anger Camera / Scintillation Camera; System components, Detector System and Electronics, Different types of Collimators, Design and performance Characteristic 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.

Unit III: Different imaging techniques and their image quality parameters

Different Imaging Techniques: Basic Principles, two dimensional Imaging Techniques, Three Dimensional Imaging techniques – Basic principles and Problems, Focal plane Tomography, Emission Computed Tomography, Single Photon Emission Computed Tomography, Positron Emission Tomography. 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.

Image Quality Parameters: Spatial Resolution, Factor affecting spatial Resolution, Methods of Evaluation of spatial Resolution, Contrast, Noise. NEMA protocols followed for quality Assurance / Quality Control of Imaging Instruments.

Unit IV: Physics of PET and Cyclotron

Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector Scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes produced and their characteristic. Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment, Radiation Synovectomy and the isotopes used. se of open isotopes including 99Tc in functional studies, measurement of radio activity, principle of isotope dilution analysis, circulation time, patient dose, guidance level, production principles and decontamination procedures.

Unit V: Internal Dosimetry

Different 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 producer and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit Cumulative Activity and problems related to the Dose calculations. Limitation of MIRD Technique.

Reference Books

1. Nuclear Particles in Cancer Treatment, J.K Fowler, Adam Hilger Ltd., Philadelphia, 1st edition (1981).
2. Nuclear Medicine, W.H.Blahd, McGraw Hill Co., New Delhi, 1st edition (1980).
3. Principles of Nuclear Medicine,W.N.Wagner,W.B.Saunders Co., London, 1stediiton (1970).
4. Text Book of Nuclear Medicine, J.Herbert and D.A.Rocha, Vol 2 and 6, Lea and Febiger Co., Philadelphia, 1st edition (1984).
5. The Physics of Medical Imaging, Medical Science Series, S.Webb, Adam Hilgers Publications, Bristol, 1st edition (1984).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - familar radioisotopes being used in different In-vitro and in-vivo studies.

CO 2 - know various types of collimator and their uses for various studies.

CO 3 - learn parameters affecting spatial resolution and methods of evaluation of spatial resoultion.

CO 4 - apply dosimetry parameters in dosimetry of radionuclides used in nuclear medicine.

CO 5- know the protocols followed for qulaity assurance / qulaity control of imaging instruments.

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Paper – 14

Title of the Subject : **Radiation Hazards Evaluation and Control** Marks:**100**

Code No. : **33D** No. of Teaching hours:**60**

Course Objectives

- To study the basic concepts of radiation protection standards, historical background and International Commission on radiation protection and its recommendations. To be familiar with ALI, DAC and International/national radiation protection standards like ICRP, BSS and AERB.
- To know about the RPR-2004 and evaluation of external radiation hazards. To study the effects of distance, time and shielding and personnel and area monitoring.
- To learn planning and shielding calculations of medical radiation installation. To recollect radiation safety during source transfer operations, special safety features in accelerators and reactors.
- To understand the treatment technique for solid, liquid and gaseous waste effluents. Explain the permissible limits for disposal of waste samples for air, water and solids.
- To know the concepts of physical protection of sources and safety and security of sources during storage, use, transport, and disposal. To recollect the radiation protection rules,applicable safety code, standards, guide and manuals.

Unit I: Radiation protection standards

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – International Commission on Radiological protection and its recommendations – The system of Radiological protection – Justification of practice, Optimization of protection and individual dose limits– potential exposures, dose and constraints – System of protection for intervention – Categories of exposures – Occupational, Public and Medical Exposures – risk factor- permissible levels for neutron flux –Factors governing internal exposure – Radionuclide concentrations in air and water – ALI, DAC and contamination levels-international/national radiation protection standards-ICRP, BSS and AERB, overview of UNSCEAR recommendations.

Unit II: Principles of Monitoring and Protection and safety in industry

RPR 2004- Evaluation of external radiation hazards – Effects of distance, time and shielding – shielding calculations – Personnel and area monitoring – Internal radiation hazards – Radio toxicity of different radionuclide and classification of laboratories – Control of contamination – Bioassay and air monitoring – chemical protection – Radiation accidents – disaster monitoring.

Safety in Industrial, Agricultural and Research uses of Radiation: Use of ionizing radiation in irradiator, industrial; radiography, nucleonic gauging, well logging and research such as medical research, industrial research and agricultural research.

Unit III: Safety in the Medical Uses of Radiation

Planning and shielding calculations of medical radiation installation – General considerations – Design of diagnostic installations- design of deep therapy, telegamma, accelerators and Brachytherapy installations, SPECT, PET/CT, Medical Cyclotron in the Nuclear Medicine Department 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 department and teletherapy departments and radioisotope laboratories – Particle accelerators protective equipment – Handling of patients – Radiation safety during sources transfer operations special safety features in accelerators, reactors.

Unit IV: Radioactive Waste Disposable and Transport of Radioisotopes

Radioactive Waste – sources of radioactive waste – Classification of waste – Treatment techniques for solid, liquid and gaseous effluents – Concept of Delay Tank and Various Waste Disposal Methods used in Nuclear Medicine. Permissible limits for disposal of waste – sampling techniques for air, water and solids – Geological, hydrological and meteorological parameters – Ecological considerations. Disposal of radioactive wastes – General methods of disposal.

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

Unit V: Legislation and Radiation Emergencies and their Medical Management

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 provisions.

National legislation – Regulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable safety codes, standards, Guides and Manuals – Regulatory Control – Licensing, inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers and Radiation workers – National Inventories of radiation sources – Import, Export procedures.

Radiation accidents and emergencies in the use of radiation sources and equipment industry and medicine - Radiographic cameras and teletherapy units – Loading and unloading of

sources – Loss of Radiation sources and their tracing – Typical accidents cases, Radiation injuries, their treatment and medical management – Case his histories.

Reference Books

1. Introduction to Health Physics, Herman Cember, McGraw-Hill Education / Medical, 4th edition (2008).
2. Atomic Energy Act No.33, 1962.
3. AERB Radiation Production Rules 2004.

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - familiar with categories of exposures and the system of radiological protection.

CO 2 – recall the principles of radiation monitoring, protection and safety in industry.

CO 3 - understand the concept of safety in the medical use of radiation.

CO 4 - familiar with radiation waste disposal and transport of radioisotopes.

CO 5 – know the importance of atomic energy act and applicable safety codes.

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Paper – 15

Title of the Subject : **Recent Advances in Radiotherapy** Marks:**100**

Code No. : **33E** No. of Teaching hours:**60**

Course Objectives

- To describe modern developments in MLC, different categories of MLC. To explain about MLC acceptance commissioning and safety assessment and clinical application.
- To be able diffentiate cone and mMLC based X-knife, Gamma knife. To be familiar with evaluation of SRS/SRT treatment plans,
- To know the concepts of kVCBCT and MVCBCT and mechanics of breathing methods to manage respiratory motion in radiation treatment.
- To understand the concepts of volumetric arc therapy, machine commissioning and quality, dosimetric aspects and treatment planning. To compare VMAt plans with conventional, IMRT planning, patients specific quality assurance,etc.
- To study the types of Total Body Irradiation treatments, equipment, principle and treatment planning, dosimetry, quality assurance and commissioning. To recall neutron capture therapy, heavy ion therapy and dosimetry.

Unit I: Conformal and Intensity Modulated Radiotherapy

Introduction to CRT with MLC-Modern developments in MLC – Different categories of MLC – Leaf position detection – commercially available MLC systems– MLC acceptance, commissioning and safety assessment – clinical application- Quality assurance.

Introduction to IMRT – physical optimization – Biological models for evaluation and optimization of IMRT – Target and critical structure definitions for IMRT – Static MLC IMRT, Dynamic MLC IMRT, compensator based IMRT –potential problems with IMRT – Commissioning and QA for IMRT treatment planning –patient specific quality assurance– IMRT delivery system quality assurance.

Unit II: Stereotactic radiosurgry/radiotherophy (SRS/SRT)

Stereotactic radiosurgry/radiotherophy (SRS/SRT) – cone and mMLC based X-Knife – Gamma Knife – immobilization devices for SRS/SRT – dosimetry and planning procedures – Evaluation of SRS/SRT treatment plans – QA protocols and procedure 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.

Unit III: Image Guided Radiation Therapy (IGRT)

Concept, imaging modality, kVCBCT and MVCBCT. Mechanics of breathing – Methods to manage respiratory motion in radiation treatment – x-ray imaging techniques for guidance in the Radiation therapy setting – clinical procedures in employing x-ray imaging technologies. –

Effect of motion on the total dose distribution – 4D computed tomography imaging and treatment planning. Delivery- QA protocol and procedures.

Unit IV: Volumetric Modulated Arc Therapy

Introduction- Machine Commissioning and Quality Assurance- Dosimetric Aspects- Treatment Planning- Comparison of VMAT treatment plans with conventional IMRT planning- Patient Specific Quality Assurance- Electronic Portal Imaging device– its clinical applications including QA tool in machine and patient specific quality assurance and gamma index analysis.

Unit V: Special Techniques in Radiation Therapy

Total Body Irradiation, hemi body irradiation, Total Skin Electron Therapy, electron arc treatment, intraoperative radiotherapy- principle, equipment, treatment planning, dosimetry, quality assurance and commissioning.

Neutron capture therapy- Heavy ion therapy (proton and carbon ion)- dosimetry (AAPM Report No 16), treatment planning, quality assurance and commissioning.

Reference Books

1. The Physics of Three–Dimensional Radiotherapy, Steve Webb, Institute of Physics Publishing, Bristol and Philadelphia, 1st edition (2002).
2. The Physics of Radiation Therapy, 3rd Edition, Faiz M Khan, Lippincott Williams & Wilkins, USA, 1st edition (2003).
3. Intensity Modulated radiation therapy, S. Webb. Institute of Physics publishing, Philadelphia, 1st edition (2001).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - narrate and introduction to IMRT.

CO 2 – patient specific QA for IMRT patients.

CO 3 - familiar with commissioning and QA of TBI and TSEI

CO 4 - understand 4D computed tomography imaging

CO 5 – know heavy ion therapy namely proton and carbon ion etc

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Title of the Subject : **Medical Physics Lab II** Marks : 1**00**
Code No. :**43P** No. of Teaching hours: **70**

Course Objectives

- To determine the calibration factor for ion chamber which is not calibrated.To determine the beam quality correction factor.To measure absolute dose for photon beam using TRS 398 protocol. To measure absolute dose for electorn beam using TRS 398 protocol.
- To measure PDD curves for different field sizes and energies. To measure flatness and symmetry for photon and electron beams.To measure R_{50}, R_{100}, R_{90} and pratical range of electron beam .
- To plot isodose distributions for carcinoma esophagus and carcinoma uterine cervix using three and four fields. To determine interleaf and intraleaf for multileaf collimator of linear accelerator. To check leaf speed and accuracy of MLC.To check variation in leaf position with gantry movement.
- To tests temporal accuracy, timer linearity and end error of brachytherapy machine. To perform source strength of Ir-192 brachytharapy source.To perform patient specific QA for IMRT patients.
- To check physical integrity of primary and secondary walls of radiotherapy installation by measuring radiation levels using survey meter.

Experiments:

1. Cross Calibration of Ion Chambers
2. Absolute Calibration of Photon and Electron beams - using TRS 398
3. Evaluation of Profile parameters using Radiation Field Analyzer
4. Manual Treatment Planning of Single and Parallel Opposed fields
5. Manual Treatment Planning of Three and Four fields
6. Quality Assurance of Multileaf Collimator
7. Quality Assurance of a Brachytherapy unit
8. Calibration of Film Scanner
9. Pretreatment IMRT Quality Assurance
10. Radiation Protection survey of Teletherapy and Brachytherapy installations

Demonstrations

(1) Nuclear Medicine uptake studies
(2) Gamma Camera demonstration
(3) Demonstration of Linear Detector Array

Reference Books

(1) The Physics of Radiation Therapy, Faiz M. Khan, Lippincott Williams & Willkins, Philadelphia, 3rd edition (2003).

(2) AAPM Report No. 72 , Basic Applications of Multileaf collimators, AAPM, USA, (2001).

(3) IAEA TRS-398, Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water, (2006).

Course Outcomes

On successful completion of the course, the students will be able to

CO 1 - measure absoulte value of radiation emitted from linear accelerator for prescribed monitor units.

CO 2 – be familar with cross calibaration of ion chamber for use in accurate measurements of radiation dose.

CO 3 - devise a treatment plan for three and four fields.

CO 4 - have in-depth knowledge in performing patient specific IMRT-QA.

CO 5 – survey radiation protection/radiotherapy installations.

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Title of the Subject : **Project Work** Marks : **300**

Code No. :**43V** No. of Teaching hours: -

Course Objectives

- To have working knowledge of the clinical diagnostic imaging and/or radiation oncology. To get hands on training with relevant instrumentation
- To be familiar with radiation safety practices and procedures including the determination of radiation shielding requirements.
- Practical real time exposure to understand the biological effects of radiation and its application for radiation safety and for radiation treatment.
- To comply with all applicable regulations and requirements regarding health and safety of self and of others, and of clinical and research ethics and procedures.
- Understanding of frontier research and to distinguish the suitable methodology for systematic analysis

Students are encouraged to spend one semester for carrying out the project work under the guidance and supervision of Medical Physicists/Scientists in leading research Hospitals/Institutes/Health Care Industries/ Universities engaged with cancer therapy/research.

Course Outcomes

On successful completion of the Project work, the students will be able to

CO1- learn various diagnostic/therapeutic instrumentation and methodology to carry out radio Therapy.

CO2 – exposed to various methods and precautions needed for their professional life as Medical Physicist.

CO3 - exposed to the state-of- the art facilities available in leading hospitals.

CO4 – learn effective communication both orally and in writing.

CO5 – understand frontier research and systematic analysis.

Project work course prepared and verified by: **Prof. Dr. P. CHRISTOPHER SELVIN**

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