MASTER OF SCIENCE
(M.Sc.)
Medical Physics

REGULATIONS & SYLLABUS

2023

JSS Academy of Higher Education & Research
(Deemed to be University) Accredited
"A++" Grade by NAAC
Sri Shivarathreeshwara Nagar, Mysuru - 570015

Overview of the program

Medical physics applies the principles of physical sciences to biomedical problems. This applied branch of physics is devoted to the application of concepts and methods from physics to the diagnosis and treatment of human disease. The courses deals with well-established and emerging areas of medical and health physics including clinical dose measurement, computing, health physics, instrumentation, medical electronics, medical imaging, physiological monitoring, physics of radiotherapy, radiobiology, and radiological imaging sciences. The coursework also contains an introduction to clinical sciences. This course must be approved by the Atomic Energy Regulatory Board (AERB), Mumbai.

Curriculum

The curriculum for M.Sc. in medical physics program is a comprehensive coverage of physics, biology, electronics and computing in medicine. It introduces students to the physical and biological basis and clinical practice of medical physics to medicine. The course is designed to provide a technical introduction to the profession of medical physics.

Duration of the course

The course is for **two** years (4 semesters) under CBCS pattern.

Career Prospectus

Completing this qualification will equip you with key transferrable skills which will be relevant to your career and for the workplace, as well as providing you with a base knowledge and understanding of medical physics at postgraduate level. You will learn to critically evaluate current research and advanced in this field of study as well as evaluating a range of research methodologies. You will learn the basic science behind radiation protection of patients and staff and be able to discuss some of the ethical issues associated with imaging and radiotherapy. Students may go on to careers in clinical service as medical physicists in research-oriented hospital settings after clinical residency training; may consider development careers in industry in radiation therapy, diagnostic radiology, or nuclear medicine or nuclear energy; in governmental organizations as radiation safety experts, or pursue academic careers in university, industry or government organizations.

Eligibility

A B.Sc. (Science) degree with 60% from UGC recognized university with Physics as one of the major subjects.

PROGRAM SPECIFIC OUTCOMES (PSOs):

By the completion of the program the student will have following Program specific outcomes.

1. Will have the ability to perform the radiation dosimetry, treatment planning for cancer
   patients and able to carry out quality assurance tests for teletherapy and brachytherapy units.

2. Will have the ability to practice all aspects of clinical medical physics for an accurate, safe and effective delivery of radiation treatment for the cancer patients and able to practice radiation safety and protection in medical institutions.

3. Can pursue a broad range of translational clinical research projects in radiotherapy.

4. Can teach medical physics courses to graduate students/Post graduate Medical students and Medical Physics students / dosimetrists.

"Vision & Mission"

"Visualizing Solutions for Accurate Diagnosis and Treatment"

Mission Statement of the Division of Medical Physics:

To conduct basic and translational research that will lead to new applications of physics for diagnosis and treatment of disease…
… by focusing on medical imaging, radiotherapy, biomagnetism, and radiation metrology. We are committed to train the students that will benefit patients in our community. Our research themes are strongly aligned with improving treatment precision using *localized* and *minimally invasive therapies* that will improve *personal patient outcomes.*

To train new generations of medical physicists…
…who will conduct research, provide professional physics service, and teach in health care facilities, laboratories and continuing a tradition of excellence in science and service.

To provide core instruction in medical physics…
… to medical students, residents, medical technologists and other students required to conduct high quality multidisciplinary training and perform state-of-the-art clinical practice.

दूरभाष / TELEPHONE : 91-22-2599 0100 / 0101
फैक्स / FAX : 91-22-2599 0650, 2558 3230
वेबसाइट / WEBSITE : www.aerb.gov.in

नियामक भवन / NIYAMAK BHAVAN,
अणुशक्तिनगर / ANUSHAKTINAGAR,
मुंबई / MUMBAI-400 094.

सत्यमेव जयते

ISO 9001:2008

भारत सरकार
GOVERNMENT OF INDIA
परमाणु ऊर्जा नियामक परिषद
ATOMIC ENERGY REGULATORY BOARD

RADIOLOGICAL SAFETY DIVISION

Dr. P. K. Dash Sharma
Head, Radiological Safety Division

Tel: (022) 2599 0656
FAX: (022) 2599 0650
E-mail: head.rsd@aerb.gov.in

Ref No.: AERB/RSD/ Med. Phy/JSS-Univ./2018/ 2385

July 19, 2018
23

Sub: M.Sc. (Medical Physics) Course

This has reference to your application for assessment of your M.Sc. (Medical Physics) course conducted at your university in collaboration with HCG Bharat Hospital and Institute of Oncology, Mysore and Narayana Health Multispecialty Hospital, Mysore in line with AERB requirements.

It has been brought to our notice by the Head, RP&AD, BARC, Mumbai that the syllabus pertaining to radiation safety aspects prescribed by AERB has been incorporated and the basic entry level qualification meets the requirements as stipulated by AERB. Therefore, AERB will have no objection if the candidates admitted in this course after issuance this letter, are employed as Medical Physicists in Medical Institutions of India after successful completion of the above course subject to the followings:

1. The course is approved by the relevant authorities.
2. Minimum syllabus prescribed by AERB including practical is covered during the course curriculum.
3. Successful completion of one year internship program from the well equipped radiation therapy department meeting AERB internship criteria after completion of M.Sc. (Medical Physics) course.

Further, Jagadguru Sri Shivarathreeshwara University, Mysore shall have to change the radiation safety syllabus, entry level qualification and duration of the programme etc. which may be recommended based on review by AERB from time to time.

Please note that the students on successful completion of M.Sc. (Medical Physics) course and completion of one year internship will have to pass an examination specified by AERB to become eligible for designation as Radiological Safety Officer in a Medical Institution.

(P.K.Dash Sharma)

The Registrar
Jagadguru Sri Shivarathreeshwara University
Mysore-570015
Karnataka

Copy to: *Head, RP&AD, BARC for information please.*

ज्ञान-विज्ञान विमुक्तये
प्रो. (डॉ.) जसपाल एस. सन्धू
सचिव
Prof. Dr. Jaspal S. Sandhu
MBBS, MS (Ortho), DSM, FAIS, FASM, FAFSM, FFIMS, FAMS
Secretary

सत्यमेव जयते

विश्वविद्यालय अनुदान आयोग
University Grants Commission
(मानव संसाधन विकास मंत्रालय, भारत सरकार)
(Ministry of Human Resource Development, Govt. of India)
बहादुरशाह ज़फ़र मार्ग, नई दिल्ली-110002
Bahadur Shah Zafar Marg, New Delhi-110002
Ph.: 011-23239337, 23236288,
Fax : 011-23238858, email : jssandhu.ugc@nic.in

D.O. No. 10-1/2010(CPP-II)

18th November, 2016

Dear Sir / Madam,

29 NOV 2016

Many universities in India conduct Post M.Sc. Diploma and Post Graduate Courses in the discipline of Medical Physics / Radiological Physics. After completion of such courses, most of the candidates opt to work as Medical Physicists in Radiotherapy Department of Cancer hospitals. Their expertise is also deployed in medical applications if radiation such as diagnostic radiology and nuclear medicine disciplines for carrying out performance evaluation / Quality Assurance tests of the radiology equipment and optimization of radiation doses to patients and occupational workers. The Medical Physicists are also eligible to be registered as Radiological Safety Officers in Medical Institutes. Availability of qualified and certified Radiological Safety Officer (RSO) is a regulatory requirement to ensure radiation safety in medical facilities.

Atomic Energy Regulatory Board has prescribed the entry level qualification, duration of the course and the radiation safety syllabus in the Atomic Energy Regulatory Board safety code for "Radiation Therapy Sources, Equipment and Installations" issued under the Atomic Energy Rules 2004. A number of institutions approach Atomic Energy Regulatory Board for checking the adequacy of their syllabus and infrastructure for conducting these courses. During assessment, it is observed that many institutions are in shortage of faculty specialized in Medical Physics or do not have separate department and these courses are being conducted as an additional program. In spite of this situation, the Medical Physics courses are being recognized / affiliated by the universities.

The Atomic Energy Regulatory Board has requested this office to ensure that prior to the commencement or affiliating any Medical Physics course, the institutions conducting such course comply with the following criteria so that skilled and competent Medical Physicists are produced in the country :

a) Requirement stipulated by Atomic Energy Regulatory Board with respect to minimum entry level qualifications, duration of the course and inclusion of prescribed radiation safety syllabus in above referred medical / radiological Physics course.
b) Availability of expert faculty of Medical Physics, adequate infrastructure, library and suitable laboratory facilities etc. in the institution / university.

In view of above, you are requested to ensure that the above criteria are being observed in the departments conducting such courses. You may also further convey relevant instructions to the colleges / institutions affiliated to your university.

With regards,

(Dr. Jaspal S. Sandhu)

Copy to :-

1. The Chairman Atomic Energy Regulatory Board, Government of India Niyamak Bhavan, Anushaktinagar, Mumbai – 400 094 (for information in reference to letter No. CH/AERB/RSD/67/2016/2527 dated 05.07.2016))
2. The Publication Officer, Website Division, UGC (for uploading in the website).

(Dr. K. Samrajya Lakshmi)
Joint Secretary

Scheme of Examination

	Semester I	Credits
Paper 1	Basics of Atomic and Nuclear Physics	4
Paper 2	Mathematical Physics	4
Paper 3	Radiation Physics and Radiation Generators	4
Paper 4	Electronics and Instrumentation	4
Elective 1*	Compulsory Elective Paper-1 Solid State Physics	4
Practical 1		6
		26
	Semester II	
Paper 5	Applied Anatomy and Physiology	4
Paper 6	Radiation Biology	4
Paper 7	Radiation Dosimetry and Standardization	4
Paper 8	Radiation Detectors and Instrumentation	4
Elective 2*	Compulsory Elective Paper-2 Applied Medical Imaging	4
Practical 2		6
		26
	Semester III	
Paper 9	External Beam Photon Therapy	4
Paper 10	Brachytherapy	4
Paper 11	Nuclear Medicine & Internal Dosimetry	4
Paper 12	Radiation Protection, Safety and Standards	4
Elective 3*	Compulsory Elective Paper-3 Special and Advanced Techniques of Radiotherapy	4
Practical 3		6
		26
	Semester IV	
	Summer Project	2
	Thesis and viva voce examination	10
	Medical Physics Tutorial	02
	Total Credits	92

*Elective Compulsory Paper: Because of JSS University following **Choice Based Credit System (CBCS) Pattern,** in CBCS there are elective papers. In Medical Physics we introduced as Compulsory Elective Papers.

Syllabus

Semester I

Paper 1
Basics of Atomic and Nuclear Physics

Unit.1 Basics of atomic physics -1

Introduction – Thomson model, Rutherford model, Rutherford's experiments on scattering of alpha particle-Bohr atom model-Basic postulates, Bohr formula, calculation of total energy of electron and Bohr's interpretation of hydrogen spectrum-Spectral series of hydrogen atom – Lyman series, Balmer series, Paschen series, Braket series and Pfund series – The energy level diagram- Correspondence principle –Definition of critical potential, excitation potential, ionization potential- Franck and Hertz's method – Davis and Goucher's method-Sommerrfield's atom model

Unit.2 Basics of Atomic Physics -2

The vector atom model-Features of vector atom model (The concept of spatial quantization and spinning electron hypothesis)- Quantum numbers – coupling schemes-Application of spatial quantization- Pauli exclusion principle-Magnetic dipole moment due to orbital motion of electron-Magnetic dipole moment due to spin- The stern and Gerlach experiment-Spin-orbit Coupling-Optical spectra-fine structure of sodium D-line-Hyperfine structure-Zeeman effect-Larmor's theorem – Quantum mechanical explanation of the normal and anomalous Zeeman effect-Pachen-Back effect and Stark effect

Unit. 3 Introduction to the Nucleus

Classification of nuclei-isotopes, isobars, isotones, isomers and mirror nuclei – General properties of nucleus-nuclear size, nuclear mass, nuclear density, nuclear charge, spin angular momentum, resultant angular momentum, nuclear magnetic dipole moments and electric quadrupole moment –Atomic mass unit-Binding energy - mass defect – stability of nucleus and binding energy-Packing fraction – Nuclear stability-Theories of nuclear composition - proton-electron hypothesis, proton-neutron hypothesis and its merits-Nuclear forces – Meson theory of nuclear forces-Model of nuclear structure-Liquid drop model, shell model and collective model

Unit.4 Radioactivity – Natural Radioactivity

Discovery of radioactivity-Natural radioactivity- Law of radioactive disintegration - Half life, mean life and measurements of decay constant – Law of successive disintegration – Natural radioactive series-Radioactive equilibrium- Secular and transient equilibrium - General properties of alpha, beta and gamma ray-Determination of E/M of alpha particles-Determination of charge of alpha particles-Velocity and range of alpha particle, experimental measurements of the range of alpha particles- Geiger and Nuttal experiment – Geiger's law-Range energy relation-Gigure-Nuttal law-Alpha particle disintegration energy-Alpha particle spectra-Theory of alpha particle decay-Determination of E/M of beta particles – Kaufmann's and Bucherer's method – Beta ray spectra-Theory of beta decay- Gamma ray emission – Origin of gamma ray- Electron capture -Internal conversion- Nuclear isomerism

Unit. 5 Radioactivity – Artificial radioactivity

The discovery of artificial transmutation – Bohr's theory of nuclear disintegration – The Q-value equation for nuclear reactions-Nuclear reactions- Exoergic and endoergic reaction-Discovery of the neutron – Basic properties of neutron – neutron charge, decay of the neutron, spin and magnetic moment of neutron, neutron diffraction and neutron mass, absorption of neutron by matter – elastic and inelastic collision – Classification of neutron – slow and fast neutron – Nuclear cross section - alpha-proton reaction, alpha-neutron reaction, proton bombardment, deuteron bombardment, neutron bombardment, photodisintegration fusion and fission - Activation of nuclides-Nuclear reactors- Elements of nuclear reactors – Nuclear reactors in India Discovery of cosmic rays-Latitude effect – Altitude effect- Primary and secondary cosmic rays – Cosmic ray showers-Cascade theory of showers

Reference books:

1. S. B. Patel, Nuclear Physics An Introduction – New Age International
2. S. N. Ghosal, Nuclear Physics, S. Chand
3. K.S. Krane, Introductory Nuclear Physics, Wiley India
4. D.C. Tayal, Nuclear Physics, Himalaya Publishing
5. S.L. Kakani and S. Kakani , Modern Physics, Viva Publications
6. R. Murugesan and Kiruthiga Sivaprasath, Modern Physics, S. Chand Publisher
7. Kenneth S.Krane, Introductory Nuclear Physics, Wiley Publisher

Paper 2
Mathematical Physics

Unit.1 Probability, Statistics and Errors

Probability - addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data
Basic ideas of statistical distributions frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis
Application to radiation detection - uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit
Binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution - additive property of normal variates, confidence limits, Bivariate distribution, Correlation and Regression, Chi-Square distribution, t-distribution, F-distribution

Unit. 2. Counting and Medical Statistics

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

Sampling and sampling distributions - confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis. Application to radiation detection – uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit.

Unit. 3. Numerical Methods

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

Unit.4 Monte Carlo:

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

Unit. 5. Computational Tools & Techniques

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

Reference books:

1. Hoffman. Numerical Methods for Engineers and Scientists – 2nd Edition Revised and Expanded, Marcel Dekker, Inc., 270 Madison Avenue, blew York, NY 10016, Marcel Dekker AG, Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland.
2. A. C. Bajpai, I. M. Calus and J. A. Fairley Numerical Methods for Engineers and Scientists – A student's course book, John Wiley & Sons
3. Walpole E, Myers R.M, Myers S.L and Ye K, "Probability & Statistics for Engineers and Scientists", Pearson Education, 2002.
4. Band W. Introduction to Mathematical Physics.
5. Croxton. Elementary Statistics
6. Dahlberg G. Statistical Method of Medical &Biology Students
7. Krasnor M.L. Ordinary Diff. Equation
8. Malvin H. Kalos and Paula A. Whitlock, Monte Carlo Methods, Wiley-VCH Verlag GmbH & CO. KGaA, Weinheim. USA, 2008.

Paper 3
Radiation Physics and Radiation Generators

Unit.1 Radiation Quantities and Units

Radiation quantities and units – Radiometry – Particle flux and fluence – Energy flux and

fluence – Cross Section – Linear and mass attenuation coefficients - Mass energy transfer and mass energy absorption coefficients - Stopping power - LET - Radiation chemical yield - W value - Dosimetry - Energy imparted - Absorbed dose - Kerma - Exposure - Air kerma Rate Constant - Charged particle equilibrium (CPE) – Relationship between Kerma, absorbed dose and exposure under CPE - Dose equivalent - Ambient and directional dose equivalents [(H*(d) and H'(d)] - Individual dose equivalent penetrating Hp(d) - Individual dose equivalent superficial Hs(d)

Unit.2 Particle Accelerators

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

Unit.3 X-ray Generators

Discovery - Production - Properties of X-rays - Characteristics and continuous spectra - Design of hot cathode X-ray tube - Basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes - Rotating anode tubes - Hooded anode tubes - Industrial X-ray tubes - X-ray tubes for crystallography - Rating of tubes - Safety devices in X-ray tubes - Rayproof and shockproof tubes - Insulation and cooling of X-ray tubes - Mobile and dental units - Faults in X-ray tubes - Limitations on loading.

Unit.4 X-ray generator circuits

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

Unit.5 Interaction of Radiation with Matter

Interaction of electromagnetic radiation 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. Introduction about NIST XCOM data base- Effective atomic number-Direct methods, interpolation method and power law method- Effective electron density
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 - Radiative collision - Bremsstrahlung - 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.
Passage of heavy charged particles through matter - Energy loss by collision - Range energy

relation - Bragg curve - Specific ionization - Stopping Power - Bethe Bloch Formula. Interaction of neutrons with matter - scattering - capture - Neutron induced nuclear reactions.

Reference books;

1. Radiation Oncology Physcis – IAEA Publication.
2. F. M. Khan Physics of Radiation Therapy.
3. H. E. Jones, J. R. Cunnighum, The Physcis of Radiology.
4. W. J. Meredith & J. B. Massey, Fudamental Physics of Radiology.
5. W. R. Handee, Medical Radiation Physics.
6. Frank Herbert Attix, Introduction to radiological physics and radiation dosimetry, John Wiley & Sons.

Paper 4
Electronics and Instrumentation

Unit.1 Analog Electronics - 1

Formation of p-n Junction diode – Forward and reverse biasing of junction diode-V-I Characteristics of junction diode-Forward and reverse bias characteristics, avalanche breakdown and dynamic resistance –Zener diode-Experimental to study the characteristics of the zener diode-Zener diode as voltage rectifier-p-n junction diode as half wave, full wave rectifier and bridge rectifier- p-n junction diode as a clippers-Positive clipper, negative clipper, biased clipper, biased combination clipper- P-N junction diode as clamping circuits-positive clamper and negative clamper
Operation amplifier: Characteristics of an OP AMP-Common mode rejection ratio (CMRR)-Slew rate-Inverting amplifier-PO-AMP application - Addition, subtraction, Integration and Differentiation - Voltage-to-current converter, Current-to-voltage converter and Logarithmic amplifier - Active amplifiers Pulse Amplifiers - DC-DC converter and RF power supplies - Switching mode power supplies - AC regulators.

Unit.2 Analog Electronics – 2

Field effective transistor (FET)- Advantages of FET over transistor-Types of FETs-Junction field effect transistor(JFET) (n and p channel JFET) – Metal oxide semiconductor field effective transistor (MOSFET) – Enhancement MOSFET and Depletion MOSFET. Oscillators – Hartley, Colpitt's, Wien-Bridge, phase shift and crystal oscillators
Integrated circuits (IC) – Fabrication of monolithic IC – Wafer-Epitaxial growth-Oxidation – Photolithographic etching process- Diffusion- Regulated power supplies using IC's

Unit. 3 Digital Electronics

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 demultiplexer circuits - BCD to Decimal decoders - Seven segment decoders - Decimal to BCD encoder - Half-adder and Full-adder. 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. 4 Microprocessor

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

Unit. 5 3D Printing Technology

What is 3D printing? – History of 3d printing technology – Elements of 3d printers- materials for 3d printers- Different types of 3d printing technology – Stereolithography (SLA)-Digital Light Processing (DLP) - Fused deposition modeling (FDM)- Selective Laser Sintering -(SLS) - Selective laser melting (SLM) - Electronic Beam Melting (EBM) – Advantages of 3d printers - Radiotherapy application of 3d printers – 3D printed bolus, beam modifier, 3d printed phantoms, 3d printed immobilization devices – 3d printing technology for intensity modulated therapy

Reference books:

1. R. Murugesan and Kiruthiga Sivaprasath, Modern Physics, S. Chand Publisher
2. S.O. Pillai, Solid state physics, New Age Science publisher
3. Santanue Chattopadhyay, A text book of electronics, New Central Book Agency
4. A.P.Malvino and D.P.Leach, Digital principles and application, MC-Graw-Hill
5. A.B. Bhattacharya, Electronic Principles and Applications, New Central Book Agency
6. Christopher Barnatt, 3D Printing: The Next Industrial Revolution, ExplainingTheFuture.com.

Compulsory Elective Paper-1

Solid State Physics

Unit 1.

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 2.

Thermal and Dielectric properties of solids - Dulong-Petits law – Einstein theory of specific heat – thermal conductivity – factors affecting thermal conductivity Basic definitions - Local

field – Clausius Mossotti relation – Electronic, Ionic, orientational and total polarizability – measurement of Dielectric constants and its measurements Ferro electricity – Electrets – Hysteresis-Piezoelectricity - Applications.

Unit 3.

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 – Anti-ferromagnetism – Molecular field theory of anti-ferromagnetism – Ferrimagnetism.

Unit 4.

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 5.

Optical Properties - Absorption processes- Photoconductivity – Photoelectric effect – Photovoltaic effect –Photoluminescene – Thermoluminescence – Flouresecnce – Radioluminesce- Phosphorescence, color centers – Types of color centers – F-Centre - Generation of color centers. MASER and LASER.

References Books:

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

Practicals for Semester I

Electronics Lab

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 SPSS.
15. Characterization of Photosensitive diodes and heel effect.
16. Statistics of Radioactive Counting
17. 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.

Semester-II
Paper 5
Applied Anatomy and Physiology

Unit. 1 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. 2 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. 3 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. 4 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. 5 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. Meschan. Normal Radiation Anatomy
2. Hollinshead W.H. Text Book of Anatomy
3. ROD R. Seely. Idho State University "Anatomy and Physiology" Eight Edition

Paper 6
Radiation Biology

Unit: 1 Cell Biology

Cell Physiology and biochemistry – Structures of the normal- nature of cancer cells- transport of ions through cell membrane- 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 – in activations, 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 – Radioprotective 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

Books for references:

1. E. J. Hall, Radiobiology for Radiologists, J. B. Lippincott Co., Philadelphia, 2000.
2. S. P. Yarmonenko, Radiobiology of Humans and animals, MIR, Publishers, Moscow, 1990.
3. Late biological effects of ionizing radiation: proceedings of the Symposium on the Late Biological Effects of Ionizing Radiation held by the International Atomic Energy Agency in Vienna, 13-17 March 1978.
4. H. Smith, J. W. Stather, Biological effects of ionizing radiation, Landolt-Börnstein- Group VIII Advanced Materials and Technologies Volume 4, 2005, pp 5-40.
5. Dr. Claus Grupen Biological Effects of Ionizing Radiation Graduate Texts in Physics 2010, pp 212-228.
6. B. Kanyár, G. J. Köteles, Dosimetry and Biological Effects of Ionizing Radiation, Handbook of Nuclear Chemistry 2011, pp 2211-2257.
7. IAEA TRS 42, Radiation Biology: A handbook for teachers and students, 2010.

Paper 7
Radiation Dosimetry and Standardization

Unit: 1 Radiation Sources

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

Unit: 2 Dosimetry & Standardization of X and Gamma Rays Beams

Standards - Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure. Limitations of FAIC. Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation. Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of Dgas, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor - N_X, N_K, N_D, air, N_D, W. IAEA TRS277: Various steps to arrive at the expression for DW starting from NX. TRS398: ND, W, Q : N_D, W : K_Q,Q0 :KQ , Derivation of an expression for KQ,Q0. Calorimetric standards - Intercomparison of standard
Measurement of DW for External beams from 60Co teletherapy machines: Reference

conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for Machine Timing error, Procedure for evaluation of Temperature and pressure correction: Thermometers and 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 photon beams from Linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, Cross calibration. Measurement of DW for high energy Electron beams from linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, Cross calibration using intermediate beam quality. Quality Audit Programmes in Reference and Non-Reference conditions.
Standardization of brachytherapy sources - Apparent activity - Reference Air Kerma Rate - Air Kerma Strength - Standards for HDR 192Ir and 60Co sources - Standardization of 125I and beta sources - IAEA TECDOC 1274 - room scatter correction. Calibration of protection level instruments and monitors.

Unit: 3 Neutron Standards & Dosimetry

Neutron classification, neutron sources, Neutron standards - primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method. Neutron spectrometry, threshold detectors, scintillation detectors & multispheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators.

Unit: 4 Standardization of Radionuclides

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

Unit :5 Radiation Chemistry and Chemical Dosimetry

Definitions of free radicals and G-value-Kinetics of radiation chemical transformations - LET and dose-rate effects - Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects - Radiation Chemistry of gases and reactions of dosimetry interest - Radiation polymerisation, effects of radiation on polymers and their applications in dosimetry - Formation of free radicals in solids and their applications in dosimetry - Description of irradiators from dosimetric view point - Dosimetry principles - Definitions of optical density, molar absorption coefficient, Beer- Lambert's law, spectrophotometry - Dose calculations - Laboratory techniques - Reagents and procedures - Requirements for an ideal chemical dosimeter - Fricke dosimeter - FBX dosimeter - Free radical dosimeter - Ceric sulphate dosimeter - Other high and low level dosimeters – Polymer gel dosimeter – Advantages of polymer gel dosimeter-Different types of polymer gel dosimeters- Characterization of polymer gel dosimeters -Dose extraction techniques of polymer gel dosimeters using x-ray CT, MRI, Optical CT, Spectrophotometer and Ultrasound- Applications of chemical

dosimeters in Radiotherapy and industrial irradiators.

Reference books:

1. Joseph Magill and Jean Galy. Radioactivity Radionuclides Radiation, European Commission Joint Research Centre, Institute for Transuranium Elements, P. O. Box 2340, 76125 Karlsruhe, Germany.
2. IAEA TRS 374, Calibration of Dosimeters used in Radiation Therapy.
3. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Viley-VCH, Verlog, 2004.
4. Field. Clinical Use of Radioisotopes.
5. J.R.Greening, Fundamentals of Radiation Dosimetry, Adam Hilger Ltd.
6. 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

Paper 8
Radiation Detectors and Instrumentation

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 – Brachytheraphy 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.

Books for References:

1. Price W.J. Nuclear Radiation Detection
2. Stepanor B.I. Theory of Luminescence
3. Glenn F Knoll. Radiation Detection & Measurement Publisher Wiley 4th edition
4. Albert Paul Malvino. Electronics Principles
5. Robert L. Boylestad. Electronics Devices and Circuit Theory
6. Paul-Horowitz. Art of Electronics
7. Greiner R.A. Semiconductor Devices & Application
8. S.S.Kapoor and V.R Ramamurthy, Nuclear Radiation Detectors, New Age International

Compulsory Elective Paper-2
Applied Medical Imaging

Unit. 1 Basic Elements of X-ray Imaging

Construction And Working Principals of Stationary and Rotating Anode X- Ray tube, Line focus Principle, Heel Effect, Filters, Beam Limiting Devices– Bremsstrahlung-characteristic line spectrum- factors affecting the x-ray spectrum

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 a 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. 2 Optimization of Image Quality and Patient Dose

Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection and slices selected for imaging, objectives of radio-diagnosis, patient dose Vs image quality. Image quality: Image quality parameters; sources of un-sharpness, reduction of un-sharpness, factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution (point spread function (PSF), line spread function (LSF), edge spread function (ESF), modulation transfer function (MTF)), focal spot size evaluation

Unit.3 Digital X-Ray Imaging and Computed Tomography

Zero-radiography, mammography, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (principle only), orthopan tomography (OPG),
Computed Tomography (CT): 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, mAS and pitch)-Other scan configurations-X-ray tubes, Collimators, Detectors-Scintillation crystal and Xenon Gas Ionization chamber, Image reconstruction - CTDI, 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 artifacts, Streak artifacts, Beam hardening artifacts and Ring artifacts, 3D Imaging –Surface reconstruction and Volumetric reconstruction.

Unit. 4 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. 5 Diagnostic Quality Assurance

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-Physics of Diagnostic Radiology by Thomas S Curry, III.
2. X-ray equipment for radiographers – Noren Chesney & Muriel Chesney.
3. The Essential Physics for Medical Imaging 3rd edition – Jerrold T Bushberg.
4. MRI in Practice – Catherine Westbrrok
5. MRI – Perry Sprawls – Medical Physics Publishing, Madison, Wisconsin-2000.
6. Basic Ultrasound – Hylton B Meire and Pat Farrant –John Wiley & Sons –NY-1994..
7. Advances in Diagnositc Medical Physics – Himalaya Publishing House-2006.
8. Meredith messay, Fundamental Physics of Radiology, Butterworth-Heinemann

Practical's for II Semester and Semester III

1. Measurement of absorbed dose to water under reference conditions for high energy photon beams (TRS 398)
2. Measurement of absorbed dose to water under reference conditions for electron beams (TRS 398)
3. Determination of percentage depth dose of high energy photon beams and electron beams using Radiation field analyzer (RFA)
4. Measurement of symmetry, flatness and penumbra of therapy beam using Radiation field analyzer (RFA)
5. Quality assurance test procedures of teletherapy machines
6. Quality assurance test procedures of brachytherapy machine
7. Radiation protection survey of teletherapy installations
8. Radiation protection survey of brachytherapy installations
9. Radiation protection survey of diagnostic radiology installations (DRP 13) (RD)
10. Radiation protection survey of a radioisotope laboratory and study of surface and air contamination (NM)]
11. Layout preparation and building Planning procedures of radiotherapy installations
12. Brachytherapy treatment planning procedures using a computerized radiotherapy treatment planning system
13. Teletherapy treatment planning procedures using a computerized radiotherapy treatment planning system

14. Calibration of Radiation monitoring instruments (Gadgets) (DRP 14)
15. Treatment plan 3DCRT, IMRT, Brachy
16. Patient specific QA – IMRT
17. QA MLC, EPID, film
18. Dose, dose rate – draw a graph
19. Demo (Radiochromic, EDR) calibration curve

Semester-III
Paper 9
External Beam Photon Therapy

Unit: 1 Beam Therapy

Description of low kV therapy x-ray units, spectral distribution of kV x-rays and effect of filtration, thoraeus filter, output calibration procedure. Construction and working of telecobalt units, source design, beam collimation and penumbra, trimmers and breast cones. Design and working of medical electron linear accelerators, beam collimation, asymmetric collimator, multileaf collimator, dose monitoring, electron contamination. Output calibration of ^{60}Co gamma rays, high energy x-rays and electron beams using IAEA TRS 398, AAPM TG 51 and other dosimetry protocols. Relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams, Radiotherapy simulator and its applications. CT and virtual simulations.

Unit: 2 Central Axis Dosimetry Parameters

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

Unit: 3 Beam Modifying and Shaping Devices

Wedge filters - universal, motorized and dynamic wedges - shielding blocks and compensators. Treatment planning in teletherapy, target volume definition and dose prescription criteria- ICRU 50 and 62 - SSD and SAD set ups - two and three dimensional localization techniques - contouring - simulation of treatment techniques - field arrangements - single, parallel opposed and multiple fields - corrections for tissue inhomogeneity, 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.

Unit: 4 Clinical Electron Beams

Energy specification - electron energy selection for patient treatment - depth dose characteristics (Ds, Dx, R100, R90, 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. Particulate beam therapy, Relative merits of electron, neutron, x-ray and gamma ray beams - Neutron capture therapy - Heavy ion therapy.

Unit: 5 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. H. E. Johns and Cunningham. The Physics of Radiology.4th edition Charles C. Thomas
2. Faiz M. Khan, The Physics of Radiation Therapy, Lippincott Williams & Wilkins, Philadelphia, 3rd edition, 2003.
3. Faiz M. Khan, Roger A. Potish, Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore, 1998.
4. S. Webb. The physics of three dimensional radiation therapy, Institute of Physics publishing, Philadelphia, 1993.
5. S. Webb. The physics of conformal radiotherapy, Institute of Physics publishing, Philadelphia, 1997.
6. S. Webb. Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 2001.
7. S.K. Jani. CT simulation for radiotherapy, Medical Physics Publishing, Madison, WI, 1993
8. J. Van Dyk. The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
9. S.C. Klevenhagen Physics and dosimetry of therapy Electron beams, Medical Physics Publishing, Madison, WI, 1996.
10. Thomas Bortfeld ·Rupert Schmidt-Ullrich, Wilfried De Neve ·David E.Wazer (Editors). Image-Guided IMRT. Springer Berlin Heidelberg, 2006.
11. D. Baltas, L. Sakelliou and N. Zamboglou The Physics of Modern Brachytherapy for Oncology CRC Press, Taylor and Francis Group, 6000 Brooken Sound Parkway NW Suite 300, Boca Raton – FL 33487-2742.
12. S. H. Levitt, J. A. Purdy, C. A. Perez and S. Vijayakumar (Editors). Technical Basis of Radiation Therapy Practical Clinical Applications - 4th Revised Edition, Springer Berlin Heidelberg New York
13. 13. G.C.bental, Radiation therapy planning, MC-Graw-Hill

Paper 10
Brachytherapy

Unit: 1 Brachytherapy Physics

Definition and classification of brachytherapy techniques - surfacemould, intracavitary, interstitial and intraluminal techniques. Requirement for brachytherapy sources - Description of radium and radium substitutes - 137Cs, 60Co, 192Ir, 125I and other commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques - Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR). Paterson Parker and Manchester Dosage systems. ICRU 38 and 58 protocols. Specification and calibration of brachytherapy sources - RAKR and 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: 2 Brachytherapy Modalities and QA

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

Unit :3 Treatment Planning in Brachytherapy

Brachytherapy treatment planning - CT/MR based brachytherapy planning - forward and inverse planning - DICOM image import / export from OT - Record & verification. Brachytherapy treatment for Prostate cancer. Ocular brachytherapy using photon and beta sources. Intravascular brachytherapy - classification - sources - dosimetry procedures - AAPM TG 60 protocol.

Unit: 4 Computers in Treatment Planning(TPS)

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. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

Unit: 5 Advanced Brachytherapy Systems

Partial breast irradiation using balloon catheter –Intra-operative Brachytherapy Integrated Brachytherapy unit-electronic brachytherapy –micro Brachytherapy- AAPM TG60 Protocol for intravascular brachytherapy

Reference Books:

1. D. Baltas, L. Sakelliou and N. Zamboglou The Physics of Modern Brachytherapy for Oncology CRC Press, Taylor and Francis Group, 6000 Brooken Sound Parkway NW Suite 300, Boca Raton – FL 33487-2742.
2. Faiz M. Khan, The Physics of radiation therapy, Lippincott Williams & Willkins, Philadelphia, 3rd edition, 2003.
3. T.J.Godden, "Physical aspects of brachytherapy". 4th edition CRC press
4. Subir Nag "Principles and Practice of Brachytheraphy".
5. S.H. Levitt, J.A. Purdy, C.A. Perez and S.Vijayakumar (Editors). Technical Basis of Radiation Therapy practical Clinical Applications – 4th Revised Edition, Springer Berlin Heidelberg New York.
6. Rachel A Powsner &Edward R powsner Esssential physics of Nuclear medicine 2nd edition, Wiley-Blackwell

Paper 11
Nuclear Medicine & Internal Dosimetry

Unit: 1 Physics of Nuclear Medicine

Introduction to Nuclear Medicine, Unsealed Sources, Production of Radionuclide used in Nuclear Medicine; Reactor based Radionuclides, Accelerator based Radionuclides, Photonuclear activation, Equations for Radionuclide Production, Radionuclide Generators and their operation principles. Various usages of Radiopharmaceuticals.
In-vivo Non-imaging procedures; Thyroid Uptake Measurements, Renogram, Life Span of RBC, Blood Volume studies, Life Span of RBC etc. General concept of Radionuclide Imaging and Historical developments.

Unit: 2 Nuclear Imaging Techniques

Radionuclide Imaging: Other techniques and Instruments; The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera / Scintillation Camera; System components, Detector System and Electronics, Different types of Collimators, Design and Performance Characteristics of the Converging, Diverging and Pin hole Collimator, Image Display and Recording Systems, Digital Image Processing Systems, Scanning Camera, Limitation of the Detector System and Electronics.
Different Imaging Techniques: Basic Principles, Two dimensional Imaging Techniques, Three Dimensional Imaging Techniques - Basic Principles and Problem, Focal Plane Tomography, Emission Computed Tomography, Single Photon Emission Computed Tomography, 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.

Unit: 3 Image Quality Parameters

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 :4 PET and Cyclotron

Physics of PET and Cyclotron: Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector ad Scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes Produced and their characteristics.
Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment, Radiation Synovectomy and the isotopes used. Concept of Delay Tank and various Waste Disposal Methods used in Nuclear Medicine. Planning and Shielding Calculations during the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

Unit :5 Internal Dosimetry

Internal Radiation 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 procedure and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit Cumulative Activity and Problems related to the Dose Calculations. Limitation of MIRD Technique.

Reference:

1. W. H. Blahd, Nuclear Medicine, McGraw Hill Co., New Delhi, 2002.
2. W. N. Wagner, Principles of Nuclear Medicine, W. B. Saunders Co., London, 1990.
3. J. Herbert and D. A. Rocha, Text Book of Nuclear Medicine, Vol. 2 and 6, Lea and Febiger Co., Philadelphia, 2002.
4. S. Webb, The Physics of Medical Imaging Medical Science Series Adam Hilger Publications, Bristol, 1990.
5. J.J Pedroso, Nuclear medicine physics, CRC Press
6. James A. Sorenson, Physics in Nuclear medicine, Web. saunders company.
7. Rachel A Powsner &Edward R powsner, Esssential physics of Nuclear medicine, Wiley-Blackwell

Paper 12
Radiation Protection, Safety and Standards

Unit: 1 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 – radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – Concepts of collective dose-Potential exposures, dose and dose constraints – System of protection for intervention - Categories of exposures – Occupational, Public and Medical Exposures - Permissible levels

for neutron flux - Factors governing internal exposure - Radionuclide concentrations in air and water - ALI, DAC and contamination levels.
Evaluation of external radiation hazards - Effects of distance, time and shielding – Shielding calculations - Personnel and area monitoring - Internal radiation hazards – Radio toxicity of different radionuclides and the classification of laboratories – Control of contamination – Bioassay and air monitoring – chemical protection – Radiation accidents – disaster monitoring

Unit: 2 Safety in the Medical uses of Radiation

Planning of medical radiation installations – General considerations – Design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories. Evaluation of radiation hazards in medical diagnostic therapeutic installations – Radiation monitoring procedures - Protective measures to reduce radiation exposure to staff and patients - Radiation hazards in brachytherapy departments and teletherapy departments and radioisotope laboratories - Particle accelerators Protective equipment - Handling of patients Waste disposal facilities - Radiation safety during source transfer operations Special safety features in accelerators, reactors.

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

Unit: 3 Radioactive Waste Disposals and Transport of Radioisotopes

Radioactive wastes – sources of radioactive wastes - Classification of waste – Treatment techniques for solid, liquid and gaseous effluents – Permissible limits for disposal of waste - Sampling techniques for air, water and solids – Geological, hydrological and meteorological parameters – Ecological considerations. Disposal of radioactive wastes - General methods of disposal - Management of radioactive waste in medical, industrial, agricultural and research establishments.
Transportation of radioactive substances - Historical background - General packing requirements - Transport documents - Labeling and marking of packages – Regulations applicable for different modes of transport - Transport by post - Transport emergencies - Special requirements for transport of large radioactive sources and fissile materials - Exemptions from regulations – Shipment approval – Shipment under exclusive use – Transport under special arrangement – Consignor's and carrier's responsibilities.

Unit: 4 Legislation

Physical protection of sources - Safety and security of sources during storage, use, transport and disposal – Security provisions: administrative and technical – Security threat and graded approach in security provision National legislation – Regulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable Safety Codes, Standards, Guides and Manuals – Regulatory Control – Licensing, Inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers and Radiation Workers – National inventories of radiation sources – Import, Export procedures

Unit: 5 Radiation Emergencies and Their Medical Management

Radiation accidents and emergencies in the use of radiation sources and equipment in

industry and medicine - Radiographic cameras and teletherapy units - Loading and unloading of sources - Loss of radiation sources and their tracing - Typical accident cases. Radiation injuries, their treatment and medical management - Case histories.

Reference Books:

1. Herman Cember. Introduction to Health Physics.
2. Atomic Energy Act 1962.
3. AERB Radiation Protection Rules 2004.
4. ICRP 1990 Recommendations.
5. ICRP 2007 Recommendations.
6. IAEA Basic Safety Standards 115, 1997.
7. Shapiro J. Radiation Protection.
8. Mckenzie. Radiation Protection in Radiotherapy

Compulsory Elective Paper-3
Special and Advanced Techniques of Radiotherapy

Unit: 1 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, and compensator based IMRT –potential problems with IMRT – Commissioning and QA for IMRT treatment planning –patient specific quality assurance– IMRT delivery system quality assurance

Unit: 2 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: 3 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: 4 Stereotactic radiosurgery/radiotherapy (SRS/SRT)

Stereotactic radiosurgery/radiotherapy (SRS/SRT) – cone and mMLC based X-Knife –

Gamma Knife – immobilization devices for SRS/SRT – dosimetry and planning procedures – Evaluation of SRS/SRT treatment plans – QA protocols and 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: 5 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. Flattening Filter Free photon beam (FFF):Introduction of FFF or true beam linac – Materials of flattening filters –Advantage (Treatment delivery, dose calculation accuracy) and disadvantages of removal of flattening filters – Characteristics of FFF beam- Dose rate – Output ratio in air – Depth dose – Surface dose- Phantom scatter factor – Profile – Out field dose - Radiation protection aspects – neutron production.

Reference Books:

1. Steve Webb, The Physics of Three–Dimensional Radiotherapy, Institute of Physics Publishing, Bristol and Philadelphia, 2002.
2. Faiz M Khan and Roger A Potish, Treatment Planning in Radiation Oncology, Williams and Wilkins, USA, 2003.
3. S. Webb. The physics of conformal radiotherapy, Institute of Physics publishing, Philadelphia, 1997.
4. S. Webb. Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 2001.
5. J. Van Dyk. The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
6. Faiz M Khan, The Physics of Radiation Therapy, 3rd edition, Lippincott Williams & Wilkins, USA, 2003.
7. Jatinder R Palta and T. Rockwell Mackie, Intensity Modulation Radiation Therapy, Medical Physics publishing, Madison, Wisconsin, 2003.
8. Thomas Bortfeld. Rupert Schmidt-Ullrich, Willfried De Neve. David E.Wazer (Editors). ImageGuided IMRT. Springer Berlin, Heidelberg, 2006.
9. AAPM Report No. 72, Basic Applications of Multileaf collimators, AAPM, USA, 2001.
10. AAPM Report No: 91, Management of Respiratory motion in radiation oncology, 2006.
11. David M. Hailey, Australian Institute of Health, High Energy Radiotherapy Equipment: A Discussion Paper, Australian Institute of Health, 1989.
12. J.F.Fowler, Nuclear Particles in Cancer Treatment, Adam Hilger Ltd., Philadelphia, Pa, 1981.

Semester IV

Summer Project
Thesis and Viva Voce Examination
Medical Physics Tutorial