NATIONAL INSTITUTE OF SCIENCE EDUCATION AND RESEARCH
(An Autonomous Institute under Dept. of Atomic Energy, Govt. of India)
PO-Jatni, Dist- Khurda, Pin-752050, website: www.niser.ac.in
Adv. No. FA-Rct./NA/02-2021

Advertisement for Scientific Officer

Applications are invited from eligible Indian citizens for recruitment in the position of **'Scientific Officer 'D' & Scientific Officer 'C'** in the Centre for Medical and Radiation Physics, NISER.

Sl #	Positions with Pay	Required Qualification & experience	Category	Age	Vacancies
1.	**Scientific Officer 'D' (Medical Physics)** Level-11, Index-1 Pay ₹67,700/-	**Essential:** Ph.D (Physics/Medical Physics) with M.Sc in Medical Physics/ Post-MSc (Physics) Diploma in Radiological Physics	UR	40 Years	01 (One)
2	**Scientific Officer 'D' (Physics)** Level-11, Index-1 Pay ₹67,700/-	**Essential:** Ph.D. in Experimental Nuclear or Particle Physics with one year post-Ph.D. experience.	UR	40 years	03 (Three)
3	**Scientific Officer 'C' (Electronics)** Level-10, Index-1 Pay ₹56,100/-	**Essential:** B.E./B.Tech. in Electronics or Communication Engineering or Instrumentation with 4 years of experience in reputed organisation **Desirable:** ME/M.Tech	UR	36 years	01 (One)
4.	**Scientific Officer 'C' (Medical Physics)** Level-10, Index-1 Pay ₹56,100/-	**Essential:** M.Sc in Radiation Biology or MSc in Medical Physics or MSc in Life sciences with biological effects of radiation as part of the course or MSc in nuclear medicine or Post-MSc (Physics) Diploma in Radiological Physics with 04 years post-MSc experience.	UR	36 Years	01 (One)

Applicants fulfilling the above eligibility criteria mentioned in brief should apply ONLINE (www.niser.ac.in) only**.** The last date for applying online is **10th June 2021**. For full details of all the aspects of the advertisement, candidates are requested to follow the advertisement at NISER web site **(https://www.niser.ac.in).**

DIRECTOR

National Institute of Science Education and Research Bhubaneswar

Advertisement for Scientific Officer

Advertisement No.: FA-Rct./NA/02-2021 **May 05, 2021**
Closing date: June 10, 2021

National Institute of Science Education and Research (NISER) Bhubaneswar, has been setup at Jatni in Khurda District of Odisha by the Department of Atomic Energy, Government of India as a unique institution of its kind pursuing undergraduate and post-graduate education in sciences combined with frontline research. The campus of NISER at Jatni is spread over a sprawling 300 acres of land on the outskirts of Bhubaneswar. It is a fully residential campus with all modern living amenities including health centre, banking facilities etc. NISER is planning to start a course on Masters in Medical and Radiological Physics (from Homi Bhabha National Institute, Mumbai).

NISER invites application from Indian citizens for the following Scientific Officer positions to be filled by direct recruitment basis for its 'Centre for Medical and Radiation Physics'.

Post Code	Post	Vacancies / Category	Pay details
01	Scientific Officer 'D' (Medical Physics)	01 (UR)	Basic Pay: 67700 Level 11 of 7th CPC Pay Matrix
02	Scientific Officer 'D' (Physics)	03 (UR)	Basic Pay: 67700 Level 11 of 7th CPC Pay Matrix
03	Scientific Officer 'C' (Electronics)	01 (UR)	Basic Pay: 56100 Level 10 of 7th CPC Pay Matrix
04	Scientific Officer 'C' (Medical Physics or Radiation Biology or Nuclear Medicine)	01 (UR)	Basic Pay: 56100 Level 10 of 7th CPC Pay Matrix

Details of Essential, Desirable Qualification, Age and experience:

Post Code-01: Scientific Officer 'D' (Medical Physics)

Number of positions : 01
Essential Qualification : Ph.D (Physics/Medical Physics) with M.Sc in Medical Physics/
Post-MSc (Physics) Diploma in Radiological Physics.
Age : Not more than 40 years (as on 05 May 2021)
Experience : At least one year post-PhD experience in any one of the following areas: Medical imaging, Radiation therapy, Radiation safety, Radiation detectors and Instrumentation.
Category : Un-Reserved
Desirable : Teaching experience at UG/PG level

Post Code-02: Scientific Officer 'D' (Physics)

Number of positions : 03
Essential Qualification : Ph.D. in Experimental Nuclear or Particle Physics
Age : Not more than 40 years (as on 05th May 2021)
Experience : At least one year Post-PhD period experience in any of the

		following areas: Gaseous based detectors or silicon based detectors or Calorimeters in nuclear/particle physics, radiation hard sensors/detectors, Muon radiography, Integrated circuits (ASICs), Commissioning and integration of complex detector systems in a laboratory of repute.
Category	:	Un-Reserved
Desirable	:	Teaching experience at UG/PG level

Post Code-03: Scientific Officer 'C' (Electronics)

Number of positions.	:	01
Essential Qualification.	:	B.E./B.Tech. in Electronics or Communication Engineering or Instrumentation
Age	:	Not more than 36 years (as on 05th May 2021)
Experience	:	At least 4 years' of post qualification experience in a reputed Organisation/institute.
Category	:	Un-Reserved
Desirable	:	M.E/ M.Tech in Electronics or Communication Engineering or Instrumentation

Post Code-04: Scientific Officer 'C' (Radiation Biology/Medical Physics/Nuclear Medicine)

Number of positions.	:	01
Essential Qualification	:	M.Sc in Radiation Biology or M.Sc in Medical Physics or M.Sc in Life sciences with biological effects of radiation as part of the course or M.Sc in nuclear medicine or Post-MSc (Physics) Diploma in Radiological Physics
Age	:	Not more than 36 years (as on 05th May 2021)
Category	:	Un-Reserved
Experience	:	At least 4 years' post MSc experience in one of the following areas: Radiotherapy or Radiation oncology or cellular effects of radiation or nuclear medicine or medical imaging
Desirable	:	Teaching experience at UG/PG level

Job Profile:

(1) To teach the theory subjects in the Master's degree course on Medical and Radiological Physics. The detailed syllabus may be checked from NISER website
(2) To set-up the teaching laboratory and take the laboratory courses related to Master's degree program in Medical and Radiological Physics.
(3) To carry out R&D related work in the broad area of detectors and instrumentations used in nuclear/particle physics experiments, sensors in radiation environment and societal applications of detectors used in nuclear and particle physics.

Shortlisting and Selection Procedure:
In case number of candidates applied for the above positions is large, NISER reserves the right to use the following as additional criteria for shortlisting applications:

(a) Consider the applicants fulfilling the desirable conditions and/or
(b) Consider the academic performance in terms of marks obtained in the masters and/or graduation level and/or
(c) Consider the years of experience after essential qualification

Final Selection will be based upon the performance in Interview only.

General information about posts advertised:

- This advertisement should not be construed as binding on NISER to make appointment.
- Based upon the requirements only the shortlisted candidates will be called for interview.

- The candidates applying for the said post must go through the detailed advertisement and ensure that they fulfill all the eligibility criteria prescribed for the said post as laid down in the advertisement.
- Applicants who are employed in Government, Semi-Government Organizations or Institutions should send their applications THROUGH PROPER CHANNEL else they will be required to produce a NO OBJECTION CERTIFICATE from their employer at the time of interview.
- Mere fulfilling the minimum eligibility criteria mentioned herein may not entitle a candidate to be called for interview. Institute reserves the right to fix higher criteria for short-listing of applications for recruitment.
- The Institute reserves the right to consider to fill or not to fill the position. The Institute has the right to set different as well as higher norms, while short-listing, taking into account the specific requirement.
- The Institute reserves the right to withdraw any advertised post(s) at any time without assigning any reason.

How to apply:

i) Only ON-LINE applications are received. The applicants should apply online through the website https://www.niser.ac.in on or before **10th June 2021**
ii) Before applying the candidate should ensure that he/she is fulfilling all the requisite qualification and experience.
iii) The candidate should have a valid email id for applying and should remain active till the completion of recruitment process.
iv) The candidate should keep the following items ready before going for apply.
   a) Soft copy (JPG file) of passport size photograph of the candidate.
   b) Scanned copy of Signature of the candidate c) Scanned copy of certificates
v) Candidates should apply online through the above mentioned website and upload proof of essential qualifications (mark sheet and certificate), proof of essential experience, age proof and documents related to desirable criteria.

Other Important Points:

1. GROUNDS OF REJECTION:
   - Application in any other mode except as described above.
   - Application of candidate not fulfilling the eligibility criteria.
   - Application without copy of relevant certificates uploaded
2. Candidate are advised to visit NISER website and their registered email id time to time for getting information regarding the recruitment process. Any information regarding the interview etc. will be informed to the candidates through their registered email ids only**.**
3. Candidates working in Govt. Organizations /Autonomous Institutions /PSU etc. should send their applications through proper channel.
4. Those who are in employment must submit a "NO OBJECTION CERTIFICATE' from the employer.

DISCLAIMER:

i. In case it is detected at any stage of recruitment that, a candidate does not fulfill the eligibility norms and/or that he/she has furnished any incorrect/false information or has suppressed any material fact(s), his/her candidature will stand cancelled. If any of these shortcomings is/are detected even after appointment, his/her services are liable to be terminated.
ii. Decision of NISER in all matters regarding eligibility, conduct of examination, other tests and selection would be final and binding on all candidates. No representation or correspondence will be entertained by the Institute in this regard.

DIRECTOR

(R111) Classical Mechanics

1. Two-body Central force problem (reduced mass), planet orbits,Virial theorem. (5 lectures)
2. Collisions and scattering, CM and lab frames, scattering cross section. (5 lectures)
3. Motion in non-inertial frames, Coriolis force. (2 lectures)
4. Principle of virtual work, constraints, D Alemberts principle. (3 lectures)
5. Generalized coordinates, velocities and momenta, Lagranges formulation. (5 lectures)
6. Principle of least action, fomulation by Maupertuls, Euler, Hamilton, Liouvilles theorem. (5 lectures)
7. Hamilton's equations, poisson brackets. (2 lectures)
8. Canonical transformation, Hamilton-Jacobi equation, Generating functions, Symetries and conservation laws. (8 lectures)
9. Small oscillations, Normal modes. (5 lectures)
10. Rigid body dynamics, Euler angles, Euler equations (5 lectures).

Reference Books:

1. Goldstein, H. (1980). Classical Mechanics. Addison-Wesley.
2. MARION, J. B., & THORNTON, S. T. (1995). Classical dynamics of particles and systems. Fort Worth, Saunders College Pub..
3. Landau, L. D. & Lifshitz, E. M. (1976), Mechanics, Third Edition: Volume 1 (Course of Theoretical Physics) , Butterworth-Heinemann .
4. Taylor, John R. (John Robert), 1939-. (2005). Classical mechanics. Sausalito, Calif. :University Science Books

(R112) Statistical Mechanics and Thermodynamics

1. Review of thermodynamics, thermodynamic potentials, thermodynamic equilibrium and stability. (5 lectures)
2. Gibbs distribution: Ensembles, classical and quantum free particles, systems with continuous and discrete spectrum, degenerate Fermi systems, Bose-Einstein condensation. (10 lectures)
3. Interacting system: Cluster and Virial expansions, radial distribution function. (5 lectures)
4. Introduction to response, fluctuation and noise, Einstein formula. (5 lectures)
5. Phase transition: phenomenology of first order and continuous phase transitions, order parameters, 1D Ising model, Iniversality and scaling, Ginzburg-Wilson theory, Spontaneous symmetry breaking. (6 lectures)
6. Fundamentals of statistical mechanics: phase space, Liouville theorem, statistical distribution theorem. (6 lectures)
7. Probability theory: Probability densities, cumulants and correlations, central limit theorem, laws of large numbers. (4 lectures)
8. Brownian motion, Langevin equation, Markov process and Fokker Planck equation. (4 lectures)

Reference Books:

1. Huang, K. (1987). Statistical Mechanics. John Wiley & Sons.
2. 2. Reif - Statistical physics
3. Mehran Kardar, Statistical physics of particles, Cambridge University Press, 2007
4. Stanley, H. Eugene (Harry Eugene), 1941, Introduction to phase transitions and critical phenomena. New York, Oxford University Press, 1971

(R113) Mathematical Physics

1. Vectors and Tensors (index notation, vector analysis in curvilinear coordinates. Cartesian tensors and four vectors, General tensors). (5 lectures)
2. Linear Algebra with emphasis on applications to physical problems (linear transformations + Matrix representations, Eigen values + Eigen Vectors, Inner product spaces). (5 lectures)

3. Complex analysis with applications (Cauchy-Riemann equations, Complex integration, Cauchy theorems, Contour integration, Branch points and branch cuts, Applications to integrals, series etc.) (5 lectures)
4. Hilbert Space methods, special functions (hilbert space, Orthonormal series expansions in Hilbert space especially Fourier series, Special functions. (5 lectures)
5. Ordinary and partial differential equations (Analysis of second order OFE's Sturm-Liouville system, Boundary value problems for Laplace Diffusion (Heat) and wave equations). (5 lectures)
6. Integral transforms, its applications and generalized functions (Laplace and Fourier transform, Dirac delta and other generalized functions, Green's functions of ODE and PDE). (5 lectures)
7. Group theory (introduction using various groups occurring in physics, its algebra, Representation of groups, Characters). (5 lectures)
8. Probability and Statistics (probability distributions, Stochastic processes like Brownian motion, Error analysis for experiments, Statistical inference). (5 lectures)

Reference Books:

1. Arfken, George B. (George Brown), 1922, Mathematical methods for physicists.Boston : Elsevier, 2005
2. Charlie Harper, Introduction to mathematical physics, Englewood Cliffs, N.J : Prentice-Hall, ©1976.
3. Tai L Chow, Mathematical methods for physicists : a concise introduction, New York: Cambridge University Press, 2000.

(R114) Electrodynamics

1. Electrostatics in vacuum, force, field, potentials and energy.(4 lectures)
2. Electrostatic boundary conditions and conductors. (2 lectures)
3. Solution of Laplace's equation in one, two and three dimensions, uniqueness theorem, methods of images, separation of variables, multipole expansion.(12 lectures)
4. Dielectrics (4 lectures)
5. Current distributions, magnetic fields and magnetostatic boundary conditions (4 lectures)
6. Motion of charges in E & B fields, energy and momentum of electromagnetic fields (8 lectures)
7. Maxwell's equations, EM waves and their propagation in free space and in media (12 lectures)
8. Potential formulation, Coulomb and Lorentz gauge, radiation from an accelerated charge, dipole radiation (10 lectures)

Reference Books:

1. David J Griffiths, Introduction to electrodynamics, Upper Saddle River, N.J. : Prentice Hall, ©1999.
2. John R Reitz; Frederick J Milford, Foundations of electromagnetic theory,Addison-Wesley Publishing Company, [1960]
3. John David Jackson, Classical electrodynamics, Wiley, [1962]
4. Dr. Munir H. Nayfeh, Dr. Morton K. Brussel, Electricity and Magnetism, Dover Publications; Illustrated edition (2015)

(R121) Quantum Mechanics

1. Hilbert space (states, operators, evolution) (2 lectures)
2. One dimensional problems & Harmonic oscillator, delta & periodic potentials (6 lectures)
3. Bound states vs scattering states (5 lectures)
4. The central force problem (2 lectures)
5. The hydrogen atom, hard and soft sphere (4 lectures)
6. Time-independent perturbation theory, WKB approximation, variational method (6 lectures)
7. Time-dependent perturbation theory, Heisenberg and interaction representations (8 lectures)

8. Dirac equation (2 lectures)
9. Scattering theory/semi classical theory of radiation/identical particles/ angular momentum/ path integrals (10 lectures)

Reference Books:

1. R. Shankar, Principles of Quantum Mechanics, Springer US, 1995
2. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Quantum Mechanics, Volume 1&II, Wiley, 1991
3. J J Sakurai; Jim Napolitano, Modern quantum mechanics, Essex (England) : Pearson, cop. 2014.
4. David Jeffery Griffiths, Introduction to Quantum Mechanics, Pearson Prentice Hall, 2005
5. Stephen Gasiorowicz, Quantum Physics, Wiley, 2003
6. Eugen Merzbacher, Quantum Mechanics, John Wiley & Sons, 1998
7. Bransden, B. H., C. J. Joachain, and B. H. Bransden. 2000. Quantum mechanics. Harlow, England: Prentice Hall.
8. Richard L. Liboff, Introductory Quantum Mechanics, Addison-Wesley, 1987

(R122) Electronics and Instrumentation

1. Foundations, passive elements (3 lectures)
2. sources – dependent sources, survey of network theorems and network analysis, transient response of R-L circuit, R-C circuits, sinusoidal steady state response, diodes and diode circuits, power supply (7 lectures)
3. rectifiers, full wave rectifier without center tapped transformer, bipolar junction transistors, constant current source, constant voltage source, field effect transistors, basic differential amplifier circuits, feedback and operational amplifiers (12 lectures)
4. digital electronics, gates, universality of certain gates, Boolean expressions, other ways of realizing logic functions, multiplexers, flip-flops and latches, counters, sequential circuits (10 lectures)
5. master slave flip-flop (S-R), edge triggered flip-flops, transducers, signal averaging, lock-in amplifier, D/A & A/D converter, multi channel analyzer (8 lectures)
6. Introduction to microcomputers and microprocessors (5 lectures)

Reference Books:

1. Paul Horowitz, Winfield Hill, The art of electronics, New York, NY, USA : Cambridge University Press, 2015.
2. Allan R. Hambley, Electronics, Prentice Hall, 2000
3. Thomas L. Floyd, Electronics Fundamentals, Prentice-Hall, Inc.
4. Earl Gates, Introduction to Electronics, Cengage Learning, 2011
5. Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, Goodwill Retail Services, Inc.
6. J MILLMAN; A GRABEL, Microelectronics, New York, N.Y. : McGraw Hill, 1988.
7. Raymond A. DeCarlo, Pen-Min Lin, Linear Circuit Analysis: Time Domain, Phasor, and Laplace Transform Approaches, Oxford University Press, 2001
8. HAYT, W H., Engineering Circuit Analysis, Tata McGraw-Hill, ©2010

(R123) Solid State Physics

1. General introduction, Drude and Sommerfeld model (4 lectures)
2. Crystal structure; x-ray diffraction (4 lectures)
3. Cohesive energy (2 lectures)
4. Blochs theorem, Band theory nearly free electrons, tight binding approximation, semi-classical dynamics of electrons in a band, motion of electrons in super-lattices, motion of atoms in an optical potential (12 lectures)
5. Semiconductors (5 lectures)
6. Thermal properties of insulators, phonons (5 lectures)
7. Landau levels - de Hass van Alphen effect and Integer quantum hall effect (5 lectures)
8. Magnetism (3 lectures)

9. Superconductivity (4 lectures)

Reference Books:

1. Kittel, Charles, Introduction to solid state physics, New York, Wiley [1966]
2. Ashcroft, Neil W., Solid state physics., New York, Holt, Rinehart and Winston [©1976]
3. H M Rosenberg, The solid state, Oxford ; New York : Oxford University Press, 1988
4. Burns, Gerald, Solid state physics. San Diego, California ; London, England : Academic Press, ©1990

(R123) Nuclear Physics

1. Nuclear systematics and stability (masses, sizes, spins, magnetic moments, quadrupole moments, energetics) and stability against particle emission, beta decay (10 lectures)
2. Nucleon-Nucleon interaction, space-time symmetries, conservation laws, isospin symmetry, low energy (effective range, shape independence, meson exchange picture (qualitative). (10 lectures)
3. Liquid drop model, compound nucleus and fission, nuclear vibrations and rotations (6 lectures)
4. Shell model, introduction to Hartree-Fock, spins and magnetic moments (8 lectures)
5. Direct nuclear reactions (3 lectures)
6. Mesons and baryons, resonances, SU(3) classification, isospin and strangeness, quark model, colour (4 lectures)
7. Weak interactions (nuclear and particle decays, neutrinos etc) (4 lectures)

Reference Books:

1. R R Roy; B P Nigam, Nuclear physics theory and experiment, New York, Wiley [1967]
2. M A Preston; Rajat K Bhaduri, Structure of the nucleus, Boca Raton, FL : CRC Press, 2018.
3. David Griffiths, Introduction to Elementary Particles,Wiley-VCH; 2 edition (2008)
4. Donald H. Perkins, Introduction to High Energy Physics, Cambridge University Press; 4 edition (2000)

(R211) RADIATION PHYSICS & RADIATION GENERATORS

1.1 Nuclear Physics 10 Lectures

Radioactivity - General properties of alpha, beta and gamma rays - Laws of radioactivity - Laws of successive transformations - Natural radioactive series - Radioactive equilibrium - Alpha ray spectra - Beta ray spectra - Theory of beta decay - Gamma emission - Electron capture - Internal conversion - Nuclear isomerism - Artificial radioactivity - Nuclear cross sections - Elementary ideas of fission and reactors - Fusion.

1.2 Particle Accelerators 10 Lectures

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.

1.3 X-ray Generators 10 Lectures

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. 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 stabilisers - 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.

1.4 Interaction of Radiation with Matter (oriented towards Radiology) 12 Lectures
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.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 - Bremmstrahlung - Range energy relation - Continuous slowing down approximation (CSDA) - straight ahead approximation and detour factors - transmission and depth dependence methods for determination of particle penetration - empirical relations between range and energy - Back scattering.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 physics : A Handbook for teachers and students. IAEA publications 2005.
2. F.M.Khan, The Physics of Radiation Therapy,Third Edition,Lippincott Williams and Wilkins,U.S.A.,2003.
3. H. E. Jones, J. R. Cunningham, The Physics of Radiology, Charles C. Thomas, New York, 2002.
4. W. J. Meredith and J. B. Massey, Fundamental Physics of Radiology, John Wright and Sons,U. K., 2000.
5. W. R. Handee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003.
6. Donald T. Graham, Paul J. Cloke, Principles of Radiological Physics, Churchill Livingstone, 2003

(R212) RADIOLOGICAL MATHEMATICS

2.1 Probability, Statistics and Errors 12 Lectures
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

2.2 Counting and Medical Statistics 6 Lectures
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.

2.3 Numerical Methods 20 Lectures

Why numerical methods, accuracy and errors on calculations - round-off error, evaluation of formulae. Iteration for Solving x = g(x), Initial Approximation and Convergence Criteria, Newton-Raphson Method. Taylor series, approximating the derivation, numerical differentiation formulas. Introduction to numerical quadrature, Trapezoidal rule, Simpson's rule, Simpson's Three-Eighth rule, Boole rule, Weddle rule. Initial value problems, Picard's method, Taylor's method, Euler's method, the modified Euler's method, Runge-Kutta method. Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

2.4 Computational Tools & Techniques 10 Lectures
Computational packages: Overview of programming in C++, MATLAB/ Mathematica, and STATISTICA in data analysis and graphics.

Reference Books:

1. Pipes L.A. & Harvil, Applied Mathematics for Engineers and Physicists, Mc Graw-Hill Book Co., New York, 1980.
2. Mary.L.Boas, Mathematical methods in the Physical Science (2nd edition), John Wiley & Sons., New York, 1983.
3. Butkov E. Mathematical Physics, Addison Wesley, New York, 1973.
4. Walpole,E, Myers,R.M, Myers,S.L and Ye,K, "Probability & Statistics for Engineers and Scientists", Pearson Education, 2002.
5. Sathyapraksh, Mathematical Physics, Sultan chand & Co., New Delhi, 1994.
6. M.K. Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing co., Madras, 1994.
7. G. Arfken and H.H. Weber, Mathematical Methods for Physicists, 4th edition, Prism Books, Bangalore, 1995.
8. Fundamentals of Mathematical Statistics,S.C.Gupta and V.K.Kapoor,S.Chan and Co:2007
9. M.K.Venkatraman, "Numerical Methods in Science and Engineering", National Publishing Company, Madras, 1996
10. Dey,P and Ghosh,M, " Programming in C", Oxford University Press, 2007.
11. Bracewell,R.N, "The Fourier Transform and its applications", McGraw Hill International Edition, 2000
12. S.S.Sastry, "Introductory Methods of Numerical Analysis", Prentice Hall of India, New Delhi, 1992.
13. Programming in ANSI C, E.Balagurusamy, Tata McGraw Hill publication , 2008.
14. J.B. Dixit, Comprehensive Programming in C and Numerical Analysis, Laxmi Publications, 2006

(R213) RADIATION DOSIMETRY AND STANDARDIZATION

3.1 Radiation Quantities and Units 6 Lectures
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)

3.2 Radiation Sources 5 Lectures
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.

3.3 Dosimetry & Standardization of X and Gamma Rays Beams
15 Lectures
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 - NX, NK, ND, air, ND, W. IAEA TRS277: Various steps to arrive at the expression for DW starting from NX. TRS398: ND, W, Q : ND, W : KQ,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, Ksat , Two voltage method for continuous and pulsed beams, Polarity correction. Measurement of DW for high-energy photon beams from Linear accelerators: Beam quality, beam quality index, beam quality correction 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.

3.4 Neutron Standards & Dosimetry 9 Lectures
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.

3.5 Standardization of Radionuclides 8 Lectures
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.

3.6 Radiation Chemistry and Chemical Dosimetry 12 Lectures
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 ¬- Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

Reference Books:

1. F M Khan-Physics of Radiation Therapy, 3rd Edition,Liippincott Williams & Wilkins,USA, 2003.
2. W. R. Hendee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003.
3. R. F. Mould, Radiotherapy Treatment Planning, Medical Physics Hand Book Series No. 7, Adam Hilger Ltd., Bristol, 1981.
4. Khan, Faiz M. Treatment Planning in Radiation Oncology, 2nd Edition Lippincott Williams & Wilkins, 2007
5. Edward C. Halperin, Carlos A. Pérez, Luther W.. Brady, Perez and Brady's principles and practice of radiation oncology, Lippincott Williams & Wilkins, 2008
6. Gunilla C. Bentel, Charles E. Nelson, K. Thomas Noell, Treatment planning and dose calculation in radiation oncology, McGraw-Hill, 1989.

(R214) RADIATION DETECTORS AND INSTRUMENTATION

4.1 Medical Electronics 5 Lectures

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

4.2 Principles of Radiation Detection 18 Lectures

Principles of Radiation detection and measurement - Basic principles of radiation detection - Gas Filled detectors - ¬Ionisation chambers - Theory and design - Construction of condenser type chambers and thimble chambers - Gas multiplication - Proportional and GM Counters - Characteristics of organic and inorganic counters - Dead time and recovery time - Scintillation detectors - Semiconductor detectors - Chemical systems - Radiographic and Radiochromic films - Thermoluminescent Dosimeters (TLD) ¬– Optically stimulated Luminescence dosimeters (OSLD) - Radiophotoluminescent dosimeters - Neutron Detectors - Nuclear track emulsions for fast neutrons - Solid State Nuclear track (SSNTD) detectors - Calorimeters - New Developments.

4.3 Radiation Measuring & Monitoring Instruments 17 Lectures

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 - Farmer Dosimeters – Radiation field analyser (RFA) - Radioisotope calibrator - Multipurpose dosimeter - Water phantom dosimetry systems - Brachytherapy dosimeters - Thermoluminescent dosimeter readers for medical applications - Calibration and maintenance of dosimeters.

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

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

Reference Books:

1. Radiation oncology physics : A Handbook for teachers and students. IAEA publications 2005.
2. F.M.Khan,The Physics of Radiation Therapy,Third Edition,Lippincott Williams and Wilkins,U.S.A.,2003
3. Samantha Morris, Radiotherapy physics and equipment, Churchill Livingstone, 2001
4. Pam Cherry, Angela Duxbury, Practical Radiotherapy: Physics and Equipment, John Wiley & Sons, 2009
5. David Greene, P.C Williams, Linear Accelerators for Radiation Therapy, Second Edition, CRC Press, 1997
6. David M. Hailey, Australian Institute of Health, High Energy Radiotherapy Equipment: A Discussion Paper, Austria

(R221) CLINICAL AND RADIATION BIOLOGY

5.1 Cell Biology 6 Lectures

Cell physiology and biochemistry - Structure of the cell - 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.

5.2 Anatomy, Physiology and Pathology 10 Lectures

Anatomy and physiology as applied to radiodiagnosis and radiotherapy - Structure & function of organs and systems & their common diseases: Skin, Lymphatic system, Bone and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and ear. Anatomy of human body, nomenclature & 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. Tumour pathology and carcinogenesis, common pathological features of cancers and interpretation of clinico-pathological data

5.3 Interaction of Radiation with Cells 6 Lectures

Action of radiation on living cells - Radiolytic products of water and their interaction with biomolecule - Nucleic acids, proteins, enzymes, fats - Influence of oxygen, temperature - Cellular effects of radiation - Mitotic delay, chromosome aberrations, mutations and recombinations - Giant cell formation, cell death ¬Recovery from radiation damage - Potentially lethal damage and sublethal damage recovery - Pathways for repair of radiation damage. Law of Bergonie and Tribondeau. Survival curve parameters - Model for radiation action - Target theory - Multihit, Multitarget - Repair misrepair hypothesis - Dual action hypothesis - Modification of radiation damage - LET, RBE, dose rate, dose fractionation - Oxygen and other chemical sensitizers - Anoxic, hypoxic, base analogs, folic acid, and energy metabolism inhibitors - Hyperthermic sensitization - Radio-protective agents.

5.4 Biological Effects of Radiation 9 Lectures

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

5.5 Clinical Aspects of Medical Imaging & Radiation Oncology
15 Lectures

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.
Site specific signs, symptoms, diagnosis and management: Head and Neck, Breast, Gynaecological, Gastro-Intestinal tract, Genito-Urinary, Lung & Thorax, Lymphomas & Leukemias & Other cancers including AIDS related cancers. Patient management on treatment - side effects related to radiation and dose - Acute & Late - Monitoring and common management of side effects - Information and communication.
Professional aspects and role of medical physicists: General patient care - Principles of professional practice - Medical terminology - Research & Professional writing - Patient privacy - Ethical & cultural issues. Legal aspects - Confidentiality, Informed consent, Health and Safety.

5.6 Biological Basis of Radiotherapy 5 Lectures
Physical and biological factors affecting cell survival, tumour regrowth and normal tissue response - Non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle - High LET radiation therapy.

5.7 Time Dose Fractionation 5 Lectures
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.

Reference Books:

1. C. H. Best and N. B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1999.
2. C. K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 2001.
3. J. R. Brobek, Physiological Basis of Medical Practice, Williams and Wilkins, London, 1995.
4. Edward Alcamo, Barbara Krumhardt, Barron's Anatomy and Physiology the Easy Way, Barron's Educational Series, 2004
5. Lippincott, Lippincott Williams & Wilkins, Anatomy and Physiology, Lippincott Williams & Wilkins, 2002
6. W. E. Arnould-Taylor, A textbook of anatomy and physiology, Nelson Thornes, 1998
7. \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.
8. 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
9. H. Smith, J. W. Stather, Biological effects of ionising radiation, Landolt-Börnstein - Group VIII Advanced Materials and Technologies Volume 4, 2005, pp 5-40
10. Dr. Claus Grupen Biological Effects of Ionizing Radiation Graduate Texts in Physics 2010, pp 212-228
11. B. Kanyár, G. J. Köteles, Dosimetry and Biological Effects of Ionizing Radiation, Handbook of Nuclear Chemistry 2011, pp 2211-2257

(R222) MEDICAL IMAGING

6.1 Principles of X-ray Diagnosis & Conventional Imaging
12 Lectures
Physical principle of diagnostic radiology: Interactions of X-rays with human body, differential transmission of x-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique Viz. superimposition of overlying structures and scatter, application of contrast media and projections at different angles to overcome superimposition of overlying structures

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

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 (grid 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, screen function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare earth screens
Radiographic Film: Components of radiographic film, physical principle of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.), QA of film developer

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

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

6.2 Digital X-Ray Imaging and Computed Tomography 10 Lectures
Xero-radiography, mammography, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (principle only), orthopan tomography (OPG), Computed Tomography (CT), QA of CT equipment

6.3 Nuclear Medicine & Internal Dosimetry 20 Lectures
Physics of Nuclear Medicine(12 L)
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.
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.

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.
In-vitro Technique: RIA/IRMA techniques and its principles.
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.
Internal Dosimetry (8 L)
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.

6.4 Magnetic Resonance Imaging (MRI) 6 Lectures
Magnetic Resonance image - proton density, relaxation time T1 & T2 images - Image characteristics - MRI system components - Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, computer functions - Imaging process – Image artifacts – MRI safety.

6.5 Ultrasound Imaging 4 Lectures
Interaction of sound waves with body tissues, production of ultrasound - transducers – acoustic coupling - image formation - modes of image display - colour Doppler.

Reference Books:

1. Christensen',s Physics of Diagnostic Radiology by Thomas S Curry, IV Edition, Lippincott Williams & Wilkins, 1990.
2. The Essential Physics for Medical Imaging – 2nd Edition –Jerrold T Bushberg, Lippincott Williams & Wilkins 2002.
3. Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 20124.
4. MRI – Perry Sprawls – Medical Physics Publishing, Madison, Wisconsin-2000
5. Advances in Diagnositc Medical Physics – Himalaya Publishing House-2006.
6. Diagnositc Ultrasound applied to OBG – Sabbahaga – Maryland -1980.
7. Essentials of Nuclear Medicine Imaging. F A Mettler,MJ Guibertau,Saunders,2005.
8. Molecular Imaging FRET Microscopy and Spectroscopy Edited by Ammasi Periasamy and Richard N Day, Oxford Press 2005

(R223) RADIATION THERAPY

7.1 Beam Therapy 25 Lectures
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 60Co 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.
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.
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.

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.

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.

7.2 Brachytherapy 10 Lectures

Definition and classification of brachytherapy techniques - surface mould, 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.

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.

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. Electronic brachytherapy (Axxent, Mammosite, etc.).

7.3 Computers in Treatment Planning 10 Lectures

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.

7.4 Special and Advanced Techniques of Radiotherapy 10 Lectures

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

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 procedures for X- and Gamma Knife units - Patient specific QA. Physical, planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy.

Intensity modulated radiation therapy (IMRT) - principles - MLC based IMRT - step and shoot and sliding window techniques - Compensator based IMRT - planning process - inverse treatment

planning - immobilization for IMRT - dose verification phantoms, dosimeters, protocols and procedures - machine and patient specific QA. Intensity Modulated Arc Therapy (IMAT e.g. Rapid Arc). Image Guided Radiotherapy (IGRT) - concept, imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures - special phantom, 4DCT. Tomotherapy - principle - commissioning - imaging - planning and dosimetry - delivery - plan adaptation - QA protocol and procedures.

Reference Books:

1. F M Khan-Physics of Radiation Therapy, 3rd Edition,Liippincott Williams & Wilkins,USA, 2003.
2. W. R. Hendee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003.
3. R. F. Mould, Radiotherapy Treatment Planning, Medical Physics Hand Book Series No. 7, Adam Hilger Ltd., Bristol, 1981.
4. Khan, Faiz M. Treatment Planning in Radiation Oncology, 2nd Edition Lippincott Williams & Wilkins, 2007
5. Edward C. Halperin, Carlos A. Pérez, Luther W.. Brady, Perez and Brady'sprinciples and practice of radiation oncology, Lippincott Williams & Wilkins, 2008
6. Gunilla C. Bentel, Charles E. Nelson, K. Thomas Noell, Treatment planning anddose calculation in radiation oncology, McGraw-Hill, 1989.
7. Radiation oncology physics : A Handbook for teachers and students. IAEA publications 2005.
8. Samantha Morris, Radiotherapy physics and equipment, Churchill Livingstone, 2001
9. David Greene, P.C Williams, Linear Accelerators for Radiation Therapy, Second Edition, CRC Press, 1997

(R224) RADIATION SAFETY

8.1 Radiation Protection standards 7 Lectures

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

8.2 Principles of Monitoring and Protection 6 Lectures

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

8.3 Safety in the Medical Uses of Radiation 15 Lectures

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 and 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.

8.4 Radioactive Waste Disposal 4 Lectures

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.

8.5 Transport of Radioisotopes 4 Lectures
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

8.6 Legislation 5 Lectures
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

8.7 Radiation Emergencies and their Medical Management 5 Lectures
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. R. F. Mold, Radiation Protection in Hospitals, Adam Hilger Ltd., Bristol, 1985.
2. Martin, A and S. A. Harbisor, An introduction to Radiation Protection, John Wiley & sons Inc., New York, 1981.
3. ICRP Publications, 1990.
4. Khan, Faiz M. Treatment Planning in Radiation Oncology, 2nd Edition Lippincott Williams & Wilkins, 2007
5. Glenn F.Knoll. Radiation Detection and Measurement,3rd edition John Wiley &Sons,Inc,2000
   Subramania Jayaraman,Lawrence H.Lanzl., Clinical Radiotherapy physics,CRC Press,Inc,1996
6. E.B.Podgorsak, Radiation Oncology Physics IAEA Publication .
7. K.N.Govindarajan Advanced Medical Radiation dosimetry, Prentice-Hall of India Pvt.Ltd,2004

Laboratory Courses (R115, R125, 215)

1. Familiarization with general laboratory equipment and identification of electronics components
2. (a) Diode characteristics (Si/Ge & Zener), (b) Half wave rectifier circuit
3. (a) Full wave bridge rectifier circuit, (b) Zener regulated power supply
4. Passive RC filters and phase shifting network
5. LCR series resonance circuit
6. Transistor characteristics
7. Single stage RC coupled amplifier
8. Study of basic configuration of OPAMP (IC-741), simple mathematical operations and its use as comparator and Schmitt trigger

9. Differentiator, Integrator and active filter circuits using OPAMP (IC-741); Phase shift oscillator using OPAMP (IC-741)
   Study of various logic families (DRL, DTL and TTL)
10. Study of Boolean logic operations using ICs
11. Design and study of full adder and subtractor circuits ;Design and study of various flip flop circuits (RS, D, JK, T); Design and study of various counter circuits (up, down, ring, mod-n) ; Design and study of astable multivibrators using IC 555.
12. Franck-Hertz Experiment
13. Photoelectric Effect
14. Emission Spectra of Metals; Emission Spectra of Hydrogen; Sodium D-line Splitting
15. Diffraction of light by ultrasonic waves
16. G.M. Counter
17. Rutherford Scattering
18. Gamma ray spectrometer
19. Compton scattering
20. Experiments using EXPEYES
21. Calibration of thermocouple using PT100 sensor

Laboratory Courses (R225)

1. Production and attenuation of bremsstrahlung.
2. Range of beta particles by Feather analysis.
3. Backscattering of beta particles and its applications.
4. Statistics of radioactive counting.
5. Study of voltage and current characteristics of an ionization chamber.
6. Calibration of survey instruments and pocket dosimeters.
7. Construction and calibration of a G.M. monitor.
8. Calibration of a therapy level dosimeter.
9. Calibration of TL phosphor & TLD reader and its use in dose distribution measurements.
10. Determination of plateau and resolving time of a G.M. counter and its application in estimating the shelf-ratio and activity of a beta source.
11. Output measurement of a gamma chamber using Fricke dosimeter.
12. Dose rate measurement of teletherapy machines using FBX dosimeter.
13. Calibration of a TLD personnel monitoring badge and dose evaluation.
14. Characteristics of a flow counter and beta activity measurement.
15. Calibration of Gamma ray spectrometer [NaI(Tl), HPGe] and identification of unknown sources using multichannel analyser.
16. Calibration and use of alanine dosimeter using ESR technique.
17. Preparation and standardization of unsealed sources.
18. Quality assurance of a diagnostic x-ray machine.
19. Evaluation of characteristics of a radiographic image.
20. Study and calibration of thyroid uptake measurement unit.
21. Dose output measurement of photon (60Co gamma rays and high energy x-rays) beams used in radiotherapy treatment.
22. Dose output measurement of electron beams used in radiotherapy treatment.
23. Determination of percentage depth dose of photon and electron beams.
24. Integrity check and calibration of low activity brachytherapy sources.
25. AKS/ RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionisation chambers.
26. In-phantom dosimetry of a brachytherapy source.
27. Familiarisation with treatment planning procedure using a computerised radiotherapy treatment planning system.
28. Survey of a radioisotope laboratory and study of surface and air contamination.
29. Absorption and backscattering of gamma rays - Determination of HVT.
30. Radiation protection survey of teletherapy installations.
31. Radiation protection survey of diagnostic radiology installations.