

# M.Sc. in MEDICAL & RADIOLOGICAL PHYSICS

*Programme Code:* PHYS26

*Programme Outcome:*

- To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary application of Medical Physics and ionising radiation safety concepts.
- To introduce advanced ideas and techniques required in emergent area of Medical Physics and radiation safety in cancer care.
- Understand and apply principles of physics for understanding the medical physics and ionising radiation safety in healthcare.
- Understand and apply mathematical techniques for describing and deeper understanding of medical physics
- Understand and apply statistical methods for describing the various radiological processes in radiation dosimetry and safety.
- Understand and apply interdisciplinary concepts and computational skills for understanding and describing the medical physics and radiation safety.
- Provide in-depth knowledge and skill in various speciality of Radiological/ Medical Physics.
- Understand and apply principles of physics for understanding the medical physics and ionizing radiation safety in healthcare.

## DETAILED COURSE STRUCTURE

**Note: L = Lecture, P = Practical, T = Tutorial.**

Year /Semester	Course Code	Course Name	L-P-T	Lectures (Hours)	Credit
1 / I	11-PHYS26-511-C	Classical Mechanics	45-0-15	60	4
1 / I	11-PHYS26-512-C	Statistical Mechanics & Thermodynamics	45-0-15	60	4
1 / I	11-PHYS26-513-C	Mathematical Physics	45-0-15	60	4
1 / I	11-PHYS26-514-C	Electrodynamics	45-0-15	60	4
1 / II	11-PHYS26-521-C	Quantum Mechanics	45-0-15	60	4
1 / II	11-PHYS26-522-C	Electronics and Instrumentation	45-0-15	60	4
1 / II	11-PHYS26-523-C	Solid State Physics	45-0-15	60	4
1 / II	11-PHYS26-524-C	Nuclear Physics	45-0-15	60	4
2 / III	11-PHYS26-611-C	Radiation Physics & Radiation Generators	45-0-15	60	4
2 / III	11-PHYS26-612-C	Radiological Mathematics	45-0-15	60	4

2 / III	11-PHYS26-613-C	Radiation Dosimetry and Standardization	45-0-15	60	4
2 / III	11-PHYS26-614-C	Radiation Detectors and Instrumentation	45-0-15	60	4
2 / IV	11-PHYS26-621-C	Clinical and Radiation Biology	45-0-15	60	4
2 / IV	11-PHYS26-622-C	Medical Imaging	45-0-15	60	4
2 / IV	11-PHYS26-623-C	Radiation Therapy	45-0-15	60	4
2 / IV	11-PHYS26-624-C	Radiation Safety	45-0-15	60	4
<b>Total credits theory</b>					<b>64</b>
1 / I	11-PHYS26-515-P	Modern Physics and Nuclear Physics Laboratory	0-112-0	112	4
1 / II	11-PHYS26-525-P	Electronics Laboratory	0-112-0	112	4
2 / III	11-PHYS26-615-P	Medical Physics Laboratory - I	0-112-0	112	4
2 / IV	11-PHYS26-625-P	Medical Physics Laboratory - II	0-112-0	112	4
<b>Total credits laboratory</b>					<b>16</b>
<b>Grand total of credits</b>					<b>80</b>

## COORDINATORS

### **Chief Coordinators:**

*Convener, Post-Graduate Committee of Centre for Medical and Radiation Physics*

*(Dr. Ranbir Singh),*

*Chairperson of Centre for Medical and Radiation Physics (Dr. Bedangadas Mohanty)*

## COURSES CO-ORDINATORS

Course	Coordinators	Email
Classical Mechanics	Dr. Ranbir Singh and Dr. Raveendrababu Karnam	<a href="mailto:ranbir.singh@niser.ac.in">ranbir.singh@niser.ac.in</a> and <a href="mailto:rkarnam@niser.ac.in">rkarnam@niser.ac.in</a>
Statistical Mechanics & Thermodynamics	Dr. Varchaswi K S Kashyap and Dr. Ranbir Singh	<a href="mailto:vkashyap@niser.ac.in">vkashyap@niser.ac.in</a> and <a href="mailto:ranbir.singh@niser.ac.in">ranbir.singh@niser.ac.in</a>
Mathematical Physics	Dr. Raveendrababu Karnam and Dr. Ganesh J Tambave	<a href="mailto:rkarnam@niser.ac.in">rkarnam@niser.ac.in</a> and <a href="mailto:ganesh.tambave@niser.ac.in">ganesh.tambave@niser.ac.in</a>
Electrodynamics	Dr. Shuddha Shankar Dasgupta and Dr. Ganesh J Tambave	<a href="mailto:shuddha@niser.ac.in">shuddha@niser.ac.in</a> and <a href="mailto:ganesh.tambave@niser.ac.in">ganesh.tambave@niser.ac.in</a>
Quantum Mechanics	Dr. Raveendrababu Karnam and Prof. Bedangadas Mohanty	<a href="mailto:rkarnam@niser.ac.in">rkarnam@niser.ac.in</a> and <a href="mailto:bedanga@niser.ac.in">bedanga@niser.ac.in</a>
Electronics and Instrumentation	Dr. Ganesh J Tambave and Dr. Varchaswi K S Kashyap	<a href="mailto:ganesh.tambave@niser.ac.in">ganesh.tambave@niser.ac.in</a> and <a href="mailto:vkashyap@niser.ac.in">vkashyap@niser.ac.in</a>
Solid State Physics	Dr. Harapasanna Lenka and Dr. Shuddha Shankar Dasgupta	<a href="mailto:hpl@niser.ac.in">hpl@niser.ac.in</a> and <a href="mailto:shuddha@niser.ac.in">shuddha@niser.ac.in</a>
Nuclear Physics	Dr. Shuddha Shankar Dasgupta and Dr. Ranbir Singh	<a href="mailto:shuddha@niser.ac.in">shuddha@niser.ac.in</a> and <a href="mailto:ranbir.singh@niser.ac.in">ranbir.singh@niser.ac.in</a>
Radiation Physics & Radiation Generators	Mr. Lalatendu Mishra and Ms. Nijun Mishra	<a href="mailto:lalatendu.mishra81@niser.ac.in">lalatendu.mishra81@niser.ac.in</a> and <a href="mailto:nijun.mishra@niser.ac.in">nijun.mishra@niser.ac.in</a>

Radiological Mathematics	Dr. Vijendra Kumar and Mr. Lalatendu Mishra	<a href="mailto:vsmedphysics@niser.ac.in">vsmedphysics@niser.ac.in</a> and <a href="mailto:lalatendu.mishra81@niser.ac.in">lalatendu.mishra81@niser.ac.in</a>
Radiation Dosimetry and Standardization	Mr. Rakesh Kumar Bhatta and Ms. Nijun Mishra	<a href="mailto:rakeshbhatta@niser.ac.in">rakeshbhatta@niser.ac.in</a> and <a href="mailto:nijun.mishra@niser.ac.in">nijun.mishra@niser.ac.in</a>
Radiation Detectors and Instrumentation	Ms. Nijun Mishra and Dr. Vijendra Kumar	<a href="mailto:nijun.mishra@niser.ac.in">nijun.mishra@niser.ac.in</a> and <a href="mailto:vsmedphysics@niser.ac.in">vsmedphysics@niser.ac.in</a>
Clinical and Radiation Biology	Dr. Vijendra Kumar and Mr. Rakesh Kumar Bhatta	<a href="mailto:vsmedphysics@niser.ac.in">vsmedphysics@niser.ac.in</a> and <a href="mailto:rakeshbhatta@niser.ac.in">rakeshbhatta@niser.ac.in</a>
Medical Imaging	Mr. Lalatendu Mishra and Mr. Rakesh Kumar Bhatta	<a href="mailto:lalatendu.mishra81@niser.ac.in">lalatendu.mishra81@niser.ac.in</a> and <a href="mailto:rakeshbhatta@niser.ac.in">rakeshbhatta@niser.ac.in</a>
Radiation Therapy	Mr. Rakesh Kumar Bhatta and Dr. Vijendra Kumar	<a href="mailto:rakeshbhatta@niser.ac.in">rakeshbhatta@niser.ac.in</a> and <a href="mailto:vsmedphysics@niser.ac.in">vsmedphysics@niser.ac.in</a>
Radiation Safety	Ms. Nijun Mishra and Dr. Vijendra Kumar	<a href="mailto:nijun.mishra@niser.ac.in">nijun.mishra@niser.ac.in</a> and <a href="mailto:vsmedphysics@niser.ac.in">vsmedphysics@niser.ac.in</a>
Modern Physics and Nuclear Physics Laboratory	Dr. Varchaswi K S Kashyap and Dr. Raveendrababu Karnam	<a href="mailto:vkashyap@niser.ac.in">vkashyap@niser.ac.in</a> and <a href="mailto:rkarnam@niser.ac.in">rkarnam@niser.ac.in</a>
Electronics Laboratory	Dr. Ganesh J Tambave and Dr. Varchaswi K S Kashyap	<a href="mailto:ganesh.tambave@niser.ac.in">ganesh.tambave@niser.ac.in</a> and <a href="mailto:vkashyap@niser.ac.in">vkashyap@niser.ac.in</a>
Medical Physics Laboratory - I	Ms. Nijun Mishra and Mr. Lalatendu Mishra	<a href="mailto:nijun.mishra@niser.ac.in">nijun.mishra@niser.ac.in</a> and <a href="mailto:lalatendu.mishra81@niser.ac.in">lalatendu.mishra81@niser.ac.in</a>
Medical Physics Laboratory - II	Mr. Lalatendu Mishra and Mr. Rakesh Kumar Bhatta	<a href="mailto:lalatendu.mishra81@niser.ac.in">lalatendu.mishra81@niser.ac.in</a> and <a href="mailto:rakeshbhatta@niser.ac.in">rakeshbhatta@niser.ac.in</a>

## CORE COURSES

### 11-PHYS26-511-C: CLASSICAL MECHANICS (60 Lecture Hrs)

**Coordinators: - Dr. Ranbir Singh and Dr. Raveendrababu Karnam**  
**Emails: ranbir.singh@niser.ac.in and rkarnam@niser.ac.in**

#### *Course Details:*

- Two-body Central force problem (reduced mass), planet orbits, Virial theorem.
- Collisions and scattering, CM and lab frames, scattering cross section.
- Motion in non-inertial frames, Coriolis force.
- Principle of virtual work, constraints, D'Alembert's principle.
- Generalized coordinates, velocities and momenta, Lagrange's formulation.
- Principle of least action, formulation by Maupertuis, Euler, Hamilton, Liouville's theorem.
- Hamilton's equations, Poisson brackets.
- Canonical transformation, Hamilton-Jacobi equation, Generating functions, Symmetries and conservation laws.
- Small oscillations, Normal modes.
- Rigid body dynamics, Euler angles, Euler equations.

#### *Course Outcomes:*

- The students will learn basic classical mechanics. It is the basis for understanding different radioactive processes and interactions.

#### *References:*

1. H. Goldstein, C.P. Poole, and J.L. Safko. Classical Mechanics. Addison Wesley, 2002. ISBN: 9780201657029.
2. S.T. Thornton and J.B. Marion. Classical Dynamics of Particles and Systems. Brooks/Cole, 2007. ISBN: 9780495556107.
3. L.D. Landau and E.M. Lifshitz. Mechanics: Volume 1. v. 1. Elsevier Science, 1982. ISBN: 9780080503479.
4. J.R. Taylor. Classical Mechanics. University Science Books, 2004. ISBN: 9781891389924.

## 11–PHYS26–512–C: STATISTICAL MECHANICS AND THERMODYNAMICS (60 Lecture Hrs)

**Coordinators: Dr. Varchaswi K S Kashyap and Dr. Ranbir Singh**  
**Emails: vkashyap@niser.ac.in and ranbir.singh@niser.ac.in**

### *Course Details:*

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

### *Course Outcomes:*

- The students will learn basic statistical mechanics. It will serve as the basis for understanding radiation transport, dosimetry and some concepts of medical imaging.

### *References:*

1. K. Huang. Statistical Mechanics. 2nd ed. Wiley India Pvt. Limited, 2008. ISBN: 9788126518494.
2. F. Reif. Statistical Physics. Tata McGraw-Hill, 2010. ISBN: 9780071322195.
3. M. Kardar. Statistical Physics of Particles. Cambridge University Press, 2007. ISBN: 9781139464871.
4. H.E. Stanley. Introduction to Phase Transitions and Critical Phenomena. International series of monographs on physics. Oxford University Press, 1987. ISBN: 9780195053166.

## 11–PHYS26–513–C: MATHEMATICAL PHYSICS (60 Lecture Hrs)

**Coordinators: Dr. Raveendrababu Karnam and Dr. Ganesh J Tambave**  
**Emails: rkarnam@niser.ac.in and ganesh.tambave@niser.ac.in**

### *Course Details:*

- Vectors and Tensors (index notation, vector analysis in curvilinear coordinates. Cartesian tensors and four vectors, General tensors).
- Linear Algebra with emphasis on applications to physical problems (linear transformations + Matrix representations, Eigen values + Eigen Vectors, Inner product spaces).
- Complex analysis with applications (Cauchy-Riemann equations, Complex integration, Cauchy theorems, Contour integration, Branch points and branch cuts, Applications to integrals, series etc.)
- Hilbert Space methods, special functions (Hilbert space, Orthonormal series expansions in Hilbert space especially Fourier series, Special functions).
- Ordinary and partial differential equations (Analysis of second order ODE's Sturm-Liouville system, Boundary value problems for Laplace Diffusion (Heat) and wave equations).
- Integral transforms, its applications and generalized functions (Laplace and Fourier transform, Dirac delta and other generalized functions, Green's functions of ODE and PDE).
- Group theory (introduction using various groups occurring in physics, its algebra, Representation of groups, Characters).
- Probability and Statistics (probability distributions, Stochastic processes like Brownian motion, Error analysis for experiments, Statistical inference).

### *Course Outcomes:*

- Students will learn mathematical physics. It is a prerequisite for understanding various concepts of advanced physics, radiation physics and imaging.

### *References:*

1. G.B. Arfken et al. Mathematical Methods for Physicists: A Comprehensive Guide. Elsevier Science, 2013. ISBN: 9780123846549.
2. C. Harper. Introduction to Mathematical Physics. Prentice-Hall physics series. Prentice-Hall, 1976. ISBN: 9780134875385.
3. T.L. Chow. Mathematical Methods for Physicists: A Concise Introduction. Cambridge University Press, 2000. ISBN: 9781139427968.

## 11–PHYS26–514–C: ELECTRODYNAMICS (60 Lecture Hrs)

**Coordinators: Dr. Shuddha Shankar Dasgupta and Dr. Ganesh J Tambave**  
**Emails: [shuddha@niser.ac.in](mailto:shuddha@niser.ac.in) and [ganesh.tambave@niser.ac.in](mailto:ganesh.tambave@niser.ac.in)**

### *Course Details:*

- Basics of electrostatics, electrostatic boundary conditions and conductors.
- Solution of Laplace’s equation in one, two and three dimensions, uniqueness theorem, methods of images, separation of variables, multipole expansion.
- Dielectrics.
- Current distributions, magnetic fields and magnetostatic boundary conditions.
- Motion of charges in E & B fields, energy and momentum of electromagnetic fields.
- Maxwell’s equations, EM waves and their propagation in free space and in media.
- Introduction to Gauge theory in Electrodynamics

### *Course Outcomes:*

- Students will learn basic electrodynamics. It will provide a basis for understanding particle production in accelerators and particle interaction with matter.

### *References:*

1. D.J. Griffiths. Introduction to Electrodynamics. Cambridge University Press, 2017. ISBN: 9781108357142.
2. J.R. Reitz. Foundations of Electromagnetic Theory. Pearson Education, 2009. ISBN: 9788131733424.
3. J.D. Jackson. Classical Electrodynamics. Wiley, 2012. ISBN: 9788126510948.
4. M.H. Nayfeh and M.K. Brussel. Electricity and Magnetism. Dover Publications, 2015. ISBN: 9780486789712.

## 11–PHYS26–521–C: QUANTUM MECHANICS (60 Lecture Hrs)

**Coordinators: Dr. Raveendrababu Karnam and Prof. Bedangadas Mohanty**  
**Emails: rkarnam@niser.ac.in and bedanga@niser.ac.in**

### *Course Details:*

- Hilbert space (states, operators, evolution).
- One dimensional problems & Harmonic oscillator, delta & periodic potentials.
- Bound states vs. scattering states.
- The central force problem.
- The hydrogen atom, hard and soft sphere.
- Time-independent perturbation theory, WKB approximation, variational method.
- Time-dependent perturbation theory, Heisenberg and interaction representations.
- Dirac equation.
- Scattering theory/semi classical theory of radiation/identical particles/angular momentum/path integrals.

### *Course Outcomes:*

- Students will learn quantum mechanics. It is the basis for understanding different radioactive processes and interactions.

### *References:*

1. R. Shankar. Principles of Quantum Mechanics. Springer US, 2012. ISBN: 9781475705768.
2. C. Cohen-Tannoudji, B. Diu, and F. Laloë. Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications. Wiley, 2019. ISBN: 9783527345533.
3. C. Cohen-Tannoudji, B. Diu, and F. Laloë. Quantum Mechanics, Volume 2: Angular Momentum, Spin, and Approximation Methods. Wiley, 2019. ISBN: 9783527345540.
4. J.J. Sakurai and J. Napolitano. Modern Quantum Mechanics. Cambridge University Press, 2020. ISBN: 9781108473224.
5. D.J. Griffiths and D.F. Schroeter. Introduction to Quantum Mechanics. Cambridge University Press, 2019. ISBN: 9781108103145.
6. S. Gasiorowicz. Quantum Physics. 3rd ed. Wiley India Pvt. Limited, 2007. ISBN: 9788126511174.
7. E. Merzbacher. Quantum Mechanics. 3rd ed. Wiley India Pvt. Limited. ISBN: 9788126533176.
8. B.H. Bransden and C.J. Joachain. Quantum Mechanics. Prentice Hall, 2000. ISBN: 9780582356917.
9. R.L. Liboff. Introductory Quantum Mechanics. Pearson Education, 2003. ISBN: 9788131704417.

## 11–PHYS26–522–C: ELECTRONICS AND INSTRUMENTATION (60 Lecture Hrs)

**Coordinators: Dr. Ganesh J Tambave and Dr. Varchaswi K S Kashyap**  
**Emails: ganesh.tambave@niser.ac.in and vkashyap@niser.ac.in**

### **Course Details:**

- Foundations, passive elements
- 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.
- 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.
- Digital electronics, gates, universality of certain gates, Boolean expressions, other ways of realizing logic functions, multiplexers, flip-flops and latches, counters, sequential circuits.
- Master slave flip-flop (S-R), edge triggered flip-flops, transducers, signal averaging, lock-in amplifier, D/A & A/D converter, multi-channel analyzer.
- Introduction to microcomputers and microprocessors.

### **Course Outcomes:**

- Students will learn basic electronics and instrumentation concepts. It will provide a basis to understand concepts in radiation detection and imaging.

### **References:**

1. P. Horowitz and W. Hill. The Art of Electronics. Cambridge University Press, 2021.
2. A.R. Hambley. Electronics. Prentice Hall, 2000. ISBN: 9780136919827.
3. T.L. Floyd. Electronics Fundamentals: Circuits, Devices, and Applications. Floyd Electronics Fundamentals Series. Pearson/Prentice Hall, 2007. ISBN: 9780132197090.
4. D. Gates. Introduction to Electronics. Delmar, 2001. ISBN: 9780766816985.
5. Op-Amps And Linear Integrated Circuits. 3rd ed. Pearson Education, 2007. ISBN: 9788177582826.
6. J. Millman and G. Arvin. Microelectronics. Tata McGraw-Hill, 1999.
7. R.A. DeCarlo and P.M. Lin. Linear Circuit Analysis: Time Domain, Phasor, and Laplace Transform Approaches : Second Edition. Oxford series in electrical and computer engineering. Oxford University Press, 2003. ISBN: 9780195667509.
8. W.H. Hayt, J.E. Kemmerly, and S.M. Durbin. Engineering Circuit Analysis. McGraw-Hill Education, 2011. ISBN: 9789814646345.

## 11–PHYS26–523–C: SOLID STATE PHYSICS (60 Lecture Hrs)

**Coordinators: Dr. Haraprasanna Lenka and Dr. Shuddha Shankar Dasgupta**  
**Emails: [hpl@niser.ac.in](mailto:hpl@niser.ac.in) and [shuddha@niser.ac.in](mailto:shuddha@niser.ac.in)**

### *Course Details:*

- General introduction, Drude and Sommerfeld model.
- Crystal structure; X-ray diffraction.
- Cohesive energy.
- Bloch's 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.
- Semiconductors.
- Thermal properties of insulators, phonons.
- Landau levels - de Hass van Alphen effect and Integer quantum hall effect.
- Magnetism

### *Course Outcomes:*

- Students will learn the basics of solid state / condensed matter physics. Useful for understanding radiation detectors, medical imaging and radiation sources.

### *References:*

1. C. Kittel, P. McEuen, and John Wiley & Sons. Introduction to Solid State Physics. John Wiley & Sons, 2015. ISBN: 9788126535187.
2. N.W. Ashcroft and N.D. Mermin. Solid State Physics. Cengage, 2021. ISBN: 9780357670811.
3. H.M. Rosenberg. The Solid State: An Introduction to the Physics of Crystals for Students of Physics, Materials Science, and Engineering. Oxford physics series. Oxford University Press, 1988. ISBN: 9780198518716.
4. G. Burns. Solid State Physics. Advances in research and applications. Academic Press, 1990. ISBN: 9780121460716.

## 11–PHYS26–524–C: NUCLEAR PHYSICS (60 Lecture Hrs)

**Coordinators: Dr. Shuddha Shankar Dasgupta and Dr. Ranbir Singh**  
**Emails: [shuddha@niser.ac.in](mailto:shuddha@niser.ac.in) and [ranbir.singh@niser.ac.in](mailto:ranbir.singh@niser.ac.in)**

### *Course Details:*

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

### *Course Outcomes:*

- Students will learn the basics of nuclear and particle physics. It is a pre-requisite for most of the medical and radiation physics courses.

### *References:*

1. R.R. Roy and B.P. Nigam. Nuclear Physics: Theory and Experiment. Wiley, 1967. ISBN: 9780471743835.
2. M.A. Preston and R.K. Bhaduri. Structure of the Nucleus. Taylor & Francis Group, 2019. ISBN: 9780367091422.
3. D. Griffiths. Introduction to Elementary Particles. Physics textbook. Wiley, 2008. ISBN: 9783527618477.
4. D.H. Perkins. Introduction to High Energy Physics. Cambridge University Press, 2000. ISBN: 9781316084984.

## 11–PHYS26–611–C: RADIATION PHYSICS AND RADIATION GENERATORS (60 Lecture Hrs)

**Coordinators: Mr. Lalatendu Mishra and Ms. Nijun Mishra**  
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### *Course Details:*

#### ▪ **Nuclear physics**

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.

#### ▪ **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.

#### ▪ **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. 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.

#### ▪ **Interaction of Radiation with Matter (oriented towards Radiology)**

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 - 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.

**Course Outcomes:**

- Students will learn about the interaction of radiation with matter, production of radioactive sources and X-rays.

**References:**

1. E.B. Podgoršak and International Atomic Energy Agency. Radiation Oncology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency, 2005. ISBN: 9789201073044.
2. F.M. Khan and J.P. Gibbons. Khan's the Physics of Radiation Therapy. Ovid mono. Lippincott Williams & Wilkins, 2014. ISBN: 9781451182453.
3. H.E. Johns and J.R. Cunningham. The Physics of Radiology. American Lecture Series, Publication No. 932. a Monograph in. Thomas, 1974. ISBN: 9780398030070.
4. W.J. Meredith and J.B. Massey. Fundamental Physics of Radiology. Elsevier Science, 2013. ISBN: 9781483284354.
5. W.R. Hendee. Medical Radiation Physics. Year Book Medical Publishers, 1970. ISBN: 9780815142393.
6. D.T. Graham and P.J. Cloke. Principles of Radiological Physics. Churchill Livingstone, 2003. ISBN: 9780443070730.

## 11-PHYS26-612-C: RADIOLOGICAL MATHEMATICS (60 Lecture Hrs)

**Coordinators: Dr. Vijendra Kumar and Mr. Lalatendu Mishra**  
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### *Course Details:*

#### ▪ **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.

#### ▪ **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.

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

#### ▪ **Computational Tools & Techniques**

Computational packages: Overview of programming in C, MATLAB / MATHEMATICA, and STATISTICA

in data analysis and graphics.

**Course Outcomes:**

- Students will learn various statistical procedures in radiation dosimetry, numerical techniques and softwares used in dose calculation.

**References:**

1. L.A. Pipes and L.R. Harvill. Applied Mathematics for Engineers and Physicists: Third Edition. Dover Books on Mathematics. Dover Publications, 2014. ISBN: 9780486794990.
2. M.L. Boas. Mathematical Methods in the Physical Sciences. Wiley student edition. Wiley, 2006. ISBN: 9788126508105.
3. E. Butkov. Mathematical Physics. Addison-Wesley Series in Advanced Physics. Addison-Wesley, 1973. ISBN: 9780201007473.
4. R.E. Walpole et al. Probability and Statistics for Engineers and Scientists. Pearson, 2017. ISBN: 9780134115856.
5. S. Prakash. Mathematical Physics: With Mechanics and Properties of Matter. Sultan Chand, 1997. ISBN: 9788170143147.
6. M.K. Venkatraman. Advanced Mathematics for Engineers & Scientists. National Publishing Co., Madras, 1994.
7. G.B. Arfken et al. Mathematical Methods for Physicists: A Comprehensive Guide. Elsevier Science, 2013. ISBN: 9780123846549.
8. S.C. Gupta and V.K. Kapoor. Fundamentals of Mathematical Statistics. Mathematical Sciences. Sultan Chand & Sons, 2020. ISBN: 9789351611738.
9. M.K. Venkatraman. Numerical Methods in Science and Engineering. National Publishing Co., Madras, 1996.
10. P. Dey and M. Ghosh. Programming in C. Oxford University Press, 2018. ISBN: 9780199491476.
11. R.N. Bracewell. The Fourier Transform and Its Applications. Circuits and systems. McGraw Hill, 2000. ISBN: 9780073039381.
12. S.S. Sastry. Introductory Methods of Numerical Analysis. Prentice-Hall of India, 2005. ISBN: 9788120327610.
13. E. Balagurusamy. Programming in ANSI C. McGraw Hill Education (India), 2017. ISBN: 9789339219666.
14. J.B. Dixit. Comprehensive Programming in C and Numerical Analysis. Laxmi Publications, 2006. ISBN: 9788170088561.

## 11–PHYS26–613–C: RADIATION DOSIMETRY AND STANDARDIZATION (60 Lecture Hrs)

Coordinators: Mr. Rakesh Kumar Bhatta and Ms. Nijun Mishra  
Emails: rakeshbhatta@niser.ac.in and nijun.mishra@niser.ac.in

### Course Details:

#### ▪ 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  $H_p(d)$  - Individual dose equivalent superficial  $H_s(d)$ .

#### ▪ 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 -  $^{125}\text{I}$  Sources - Beta ray applicators - Thermal and fast neutron sources - Preparation of tracers and labelled compounds - Preparation of radio colloids.

#### ▪ 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  $D_{\text{gas}}$ , 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, Q Calorimetric standards - Intercomparison of standard. Measurement of DW for External beams from  $^{60}\text{Co}$  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,  $K_{\text{sat}}$ , 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  $^{192}\text{Ir}$  and  $^{60}\text{Co}$  sources Standardization of  $^{125}\text{I}$  and beta sources - IAEA TECDOC 1274 - room scatter correction. Calibration of

protection level instruments and monitors.

▪ **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 & multi- spheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators.

▪ **Standardization of Radionuclides**

Methods of measurement of radioactivity - Defined solid angle and  $4\pi$  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,  $\gamma$ ) and (n, p) reactions – Determination of yield of neutron sources - Space integration methods - Solid state detectors.

▪ **Radiation Chemistry and Chemical Dosimetry**

Definitions of free radicals and G-value-Kinetics of radiation chemical trans- formations - 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.

**Course Outcomes:**

- Students will gain in-depth knowledge about radiation sources, their standardization and different dosimetric procedures.

**References:**

1. F.M. Khan and J.P. Gibbons. Khan's the Physics of Radiation Therapy. Ovid mono. Lippincott Williams & Wilkins, 2014. ISBN: 9781451182453.
2. H.E. Johns and J.R. Cunningham. The Physics of Radiology. American Lecture Series, Publication No. 932. a Monograph in. Thomas, 1974. ISBN: 9780398030070.
3. F.M. Khan. Treatment Planning in Radiation Oncology. LWW medical book collection. Lippincott Williams & Wilkins, 2007. ISBN: 9780781785419.
4. E.C. Halperin, C.A. Perez, and L.W. Brady. Perez and Brady's Principles and Practice of Radiation Oncology. Perez and Brady's Principles and Practice of Radiation Oncology. Wolters Kluwer Health/Lippincott Williams & Wilkins, 2008. ISBN: 9780781763691.

5. G.C. Bentel, C.E. Nelson, and K.T. Noell. *Treatment Planning and Dose Calculation in Radiation Oncology*. Elsevier Science, 2014. ISBN: 9781483280417.

## 11–PHYS26–614–C: RADIATION DETECTORS AND INSTRUMENTATION (60 Lecture Hrs)

**Coordinators: Ms. Nijun Mishra and Dr. Vijendra Kumar**  
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### *Course Details:*

#### ▪ **Medical Electronics**

Semiconductor diodes - JFET – MOSFET – Integrated Circuits - Operational amplifiers (OPAMP) and their characteristics - Differential Amplifier - Operational amplifier systems – OPAMP Applications - Addition, subtraction, Integration and Differentiation - Active amplifiers - Pulse Amplifiers - De- coders 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.

#### ▪ **Principles of Radiation Detection**

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.

#### ▪ **Radiation Measuring & Monitoring 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 - 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.

### *Course Outcomes:*

- Students will gain in-depth understanding about different radiation detectors and instruments.

**References:**

1. E.B. Podgoršak and International Atomic Energy Agency. Radiation Oncology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency, 2005. ISBN: 9789201073044.
2. F.M. Khan. The Physics of Radiation Therapy. Wolters Kluwer Health, 2012. ISBN: 9781451149135.
3. S. Morris and W. Williams. Radiotherapy Physics and Equipment. Churchill Livingstone, 2001. ISBN: 9780443062117.
4. P. Cherry and A.M. Duxbury. Practical Radiotherapy: Physics and Equipment. Wiley, 2009. ISBN: 9781444316186.
5. D. Greene and P.C. Williams. Linear Accelerators for Radiation Therapy. CRC Press, 2017. ISBN: 9781000064957.
6. David M. Hailey. High Energy Radiotherapy Equipment. A discussion paper by the National Health Technology Advisory Panel. Canberra. Australian Institute of Health, Australia.

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## 11–PHYS26–621–C: CLINICAL AND RADIATION BIOLOGY (60 Lecture Hrs)

Coordinators: Dr. Vijendra Kumar and Mr. Rakesh Kumar Bhatta  
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### Course Details:

#### ▪ Cell Biology

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.

#### ▪ Anatomy, Physiology and Pathology

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, Radio- graphic 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.

#### ▪ Interaction of Radiation with Cells

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 - Hyper- thermic sensitization - Radio- protective agents.

#### ▪ 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 dose - Effect of radiation on skin and blood forming organs, digestive tract - Sterility and cataract formation - Effects of chronic exposure to radiation - Induction of leukaemia - Radiation Carcinogenesis – Risk of carcinogenesis - Animal and human data - Shortening of life span - In-utero exposure - Genetic effects of radiation - Factors affecting frequency of radiation induced mutations - Dose-effect relationship - first generation effects - Effects due to mutation of recessive characteristics - Genetic burden - Prevalence of hereditary diseases and defects – Spontaneous mutation rate - Concept of doubling dose and genetic risk estimate.

▪ **Clinical Aspects of Medical Imaging & Radiation Oncology**

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.

▪ **Biological Basis of Radiotherapy**

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.

▪ **Time Dose Fractionation**

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.

**Course Outcomes:**

- Students will learn about basic human anatomy, physiology, the effects of ionizing radiation on biological systems and clinical aspects of radiation therapy.

**References:**

1. Charles H. Best and Norman Burke Taylor. The Physiological Basis of Medical Practice; A Text in Applied Physiology. 6th ed. Williams & Wilkins Co., Baltimore, 1955.
2. C.K. Warrick. Anatomy and Physiology for Radiographers. Edward Arnold, 1969. ISBN: 9780713141504.
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4. B. Krumhardt and I.E. Alcamo. Barron's E-Z Anatomy and Physiology. E-Z series. Barron's Educational Series, 2010. ISBN: 9781784025229.
5. L. Bruck et al. Anatomy and physiology: made incredibly easy. Lippincott Williams and Wilkins, 2005.
6. W. Arnould-Taylor. A Textbook of Anatomy and Physiology. Stanley Thornes, 1998. ISBN: 9780748736348.
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10. H. Smith and J. W. Stather. "2 Biological effects of ionising radiation: Datasheet from Landolt-Börnstein - Group VIII Advanced Materials and Technologies · Volume 4: "Radiological Protection" in SpringerMaterials". In: ed. by A. Kaul and D. Becker. Copyright 2005 Springer-Verlag Berlin Heidelberg, Part of Springer Materials, accessed 2024-01-17. Springer-Verlag Berlin Heidelberg. doi: 10.1007/10723325\_2.
11. Claus Grupen. "Biological Effects of Ionizing Radiation". In: Introduction to Radiation Protection: Practical Knowledge for Handling Radioactive Sources. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 212–228. ISBN: 978-3-642-02586-0. doi: 10.1007/978-3-642-02586-0\_13.
12. B. Kanyár and G. J. Köteles. "Dosimetry and Biological Effects of Ionizing Radiation". In: Handbook of Nuclear Chemistry. Ed. by Attila Vértes et al. Boston, MA: Springer US, 2011, pp. 2211–2257. ISBN: 978-1-4419-0720-2. doi: 10.1007/978-1-4419-0720-2\_47.

## 11-PHYS26-622-C: MEDICAL IMAGING (60 Lecture Hrs)

**Coordinators: Mr. Lalatendu Mishra and Mr. Rakesh Kumar Bhatta**  
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### Course Details:

#### ▪ Principles of X-ray Diagnosis & Conventional Imaging

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, sensitometric parameters of film (density, speed, latitude etc.), QA of film developer.

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

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

#### ▪ Digital X-Ray Imaging and Computed Tomography

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.

#### ▪ Magnetic Resonance Imaging (MRI)

Magnetic Resonance image - proton density, relaxation time T1 & T2 images - Image characteristics - MRI

system components - Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, computer functions - Imaging process - Image artifacts - MRI safety.

- **Ultrasound Imaging**

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

- **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.

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 and 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**

Different Compartmental Model; Single Compartmental Model, Two Compartmental Model with Back Transference, Two Compartmental Model with- out 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. MIRN 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 MIRN Technique.

**Course Outcomes:**

- Students will gain knowledge about the concepts of medical imaging, nuclear medicine and internal dosimetry.

**References:**

1. T.S. Curry, J.E. Dowdey, and R.C. Murry. Christensen's Physics of Diagnostic Radiology. Lippincott Williams & Wilkins, 1990. ISBN: 9780812113105.
2. J.T. Bushberg. The Essential Physics of Medical Imaging. Lippincott Williams & Wilkins, 2002. ISBN: 9780683301182.
3. J.A. Pope. Medical Physics. Options in physics. Heinemann Educational, 1989. ISBN: 9780435686826.
4. P. Sprawls. Magnetic Resonance Imaging: Principles, Methods, and Techniques. Medical Physics Publishing, 2000. ISBN: 9781951134044.
5. G.S. Pant. Advances in Diagnostic Medical Physics. Himalaya Publishing House, 2006. ISBN: 9789350440957.
6. R.E. Sabbagha. Diagnostic Ultrasound Applied to Obstetrics and Gynecology. Medical Department, Harper & Row, 1980. ISBN: 9780061423109.
7. F.A. Mettler and M.J. Guiberteau. Essentials of Nuclear Medicine Imaging. Saunders/Elsevier, 2006. ISBN: 9780721602011.
8. A. Periasamy, R. Day, and American Physiological Society (1887-). Molecular Imaging: FRET Microscopy and Spectroscopy. Methods in physiology series. Elsevier Science, 2005. ISBN: 9780195177206.

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## 11-PHYS26-623-C: RADIATION THERAPY (60 Lecture Hrs)

**Coordinators: Mr. Rakesh Kumar Bhatta and Dr. Vijendra Kumar**  
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### *Course Details:*

#### ▪ **Beam Therapy**

Description of low kV therapy X-ray units - spectral distribution of kV X-rays and effect of filtration - thoraesus 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  $^{60}\text{Co}$  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. 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 field 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.

#### ▪ **Brachytherapy**

Definition and classification of brachytherapy techniques - surface mould, intracavitary, interstitial and intraluminal techniques. Requirement for brachytherapy sources - Description of radium and radium substitutes -  $^{137}\text{Cs}$ ,  $^{60}\text{Co}$ ,  $^{192}\text{Ir}$ ,  $^{125}\text{I}$  and other commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques - Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR). Paterson Parker and Manchester Dosage systems. ICRU 38 and 58 protocols. Specification and calibration of brachytherapy sources - RAKR and 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.).

#### ▪ **Computers in Treatment Planning**

Scope of computers in radiation treatment planning - Review of algorithms used for treatment planning computations - Pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam, and brachytherapy - Factors to be incorporated in computational algorithms. Plan optimization - direct aperture optimization - beamlet optimization - simulated annealing - dose volume histograms - Indices used for plan comparisons Hardware and software requirements - beam & source library generation. Networking, DICOM and PACS. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

#### ▪ **Special and Advanced Techniques of Radiotherapy**

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.

**Course Outcomes:**

- Students will learn about the therapeutic use of radiation like: teletherapy, brachytherapy etc. and advanced techniques in radiotherapy, usage of computers and algorithms.

**References:**

1. J.P. Gibbons. Khan's the Physics of Radiation Therapy. M - Medicine Series. Wolters Kluwer, 2019. ISBN: 9781496397522.
2. W.R. Hendee. Medical Radiation Physics. Year Book Medical Publishers, 1970. ISBN: 9780815142393.
3. R. F. Mould. Radiotherapy Treatment Planning, (Medical Physics Handbook 14). 1st ed. CRC Press, 1985. ISBN: 9780852747889.
4. F.M. Khan. Treatment Planning in Radiation Oncology. LWW medical book collection. Lippincott Williams & Wilkins, 2007. ISBN: 9780781785419.
5. E.C. Halperin et al. Perez and Brady's Principles and Practice of Radiation Oncology. M - Medicine Series. Wolters Kluwer, 2018. ISBN: 9781496386793.
6. G.C. Bentel, C.E. Nelson, and K.T. Noell. Treatment Planning and Dose Calculation in Radiation Oncology. McGraw-Hill, Incorporated, 1989. ISBN: 9780071052467.
7. E.B. Podgoršak and International Atomic Energy Agency. Radiation Oncology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency, 2005. ISBN: 9789201073044.
8. S. Morris and A.W. (DCR. Radiotherapy Physics and Equipment. Churchill Livingstone, 2001. ISBN: 9780443062117.
9. D. Greene and P.C. Williams. Linear Accelerators for Radiation Therapy. CRC Press, 2017. ISBN: 9781000064957.

## 11-PHYS26-624-C: RADIATION SAFETY (60 Lecture Hrs)

Coordinators: Ms. Nijun Mishra and Dr. Vijendra Kumar  
Emails: [nijun.mishra@niser.ac.in](mailto:nijun.mishra@niser.ac.in) and [vsmedphysics@niser.ac.in](mailto:vsmedphysics@niser.ac.in)

### Course Details:

#### ▪ 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, Optimisation of Protection and individual dose limits – Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – Concepts of collective dose- Potential exposures, dose and dose constraints – System of protection for intervention - Categories of exposures – Occupational, Public and Medical Exposures - Permissible levels for neutron flux - Factors governing internal exposure - Radionuclide concentrations in air and water - ALI, DAC and contamination levels.

#### ▪ Principles of Monitoring and Protection

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

#### ▪ Safety in the Medical Uses of Radiation

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.

#### ▪ Radioactive Waste Disposal

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.

#### ▪ Transport of Radioisotopes

Transportation of radioactive substances - Historical background - General packing requirements - Transport

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

▪ **Legislation**

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.

▪ **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.

**Course Outcomes:**

- Students will gain knowledge about radiation protection of individuals and radiation facilities, disposal of radioactive waste, safety aspects of radioactive material transport and various rules and regulations related to radiation protection.

**References:**

1. R.F. Mould. Radiation Protection in Hospitals, Taylor & Francis, 1985. ISBN: 9780852748022.
2. A.M.S.A. Harbison. An Introduction to Radiation Protection. Springer US, 2014. ISBN: 9781489969415.
3. F.M. Khan. Treatment Planning in Radiation Oncology. LWW medical book collection. Lippincott Williams & Wilkins, 2007. ISBN: 9780781785419.
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5. G.F. Knoll. Radiation Detection and Measurement. Wiley, 2010. ISBN: 9780470131480.
6. E.F. Lanzl, S. Jayaraman, and L.H. Lanzl. Clinical Radiotherapy Physics. Springer Berlin Heidelberg, 2011. ISBN: 9783642185496.
7. E.B. Podgoršak and International Atomic Energy Agency. Radiation Oncology Physics: A Handbook for Teachers and Students. International Atomic Energy Agency, 2005. ISBN: 9789201073044.
8. K.N.G. Rajan. Advanced Medical Radiation Dosimetry. Prentice Hall India Pvt., Limited, 2004. ISBN: 9788120307063.

## LABORATORY COURSES

### **11–PHYS26–515–P: MODERN PHYSICS AND NUCLEAR PHYSICS LABORATORY (112 Lab hours)**

**Coordinators: Dr. Varchaswi K S Kashyap and Dr. Raveendrababu Karnam**  
**Emails: vkashyap@niser.ac.in and rkarnam@niser.ac.in**

#### *Course Details:*

- Franck-Hertz Experiment.
- Photoelectric Effect.
- Emission Spectra of Metals; Emission Spectra of Hydrogen; Sodium D-line Splitting.
- Diffraction of light by ultrasonic waves.
- G. M. Counter.
- Rutherford Scattering.
- Gamma ray spectrometer.
- Compton scattering.
- Experiments using EXPEYES.
- Calibration of thermocouple using PT-100 sensor.

#### *Course Outcomes:*

- Students will gain hands on experience with basic experiments in modern and nuclear physics.

## **11–PHYS26–525–P: ELECTRONICS LABORATORY** **(112 Lab hours)**

**Coordinators: Dr. Ganesh J Tambave and Dr. Varchaswi K S Kashyap**  
**Emails: ganesh.tambave@niser.ac.in and vkashyap@niser.ac.in**

### ***Course Details:***

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

### ***Course Outcomes:***

- Students will gain hands on experience with analog and digital electronic circuits used for processing signals from radiation detectors.

## **11–PHYS26–615–P: MEDICAL PHYSICS LABORATORY – I** **(112 Lab hours)**

**Coordinators: Ms. Nijun Mishra and Mr. Lalatendu Mishra**  
**Emails: nijun.mishra@niser.ac.in and lalatendu.mishra81@niser.ac.in**

### ***Course Details:***

- Production and attenuation of bremsstrahlung.
- Range of beta particles by Feather analysis.
- Backscattering of beta particles and its applications.
- Statistics of radioactive counting.
- Study of voltage and current characteristics of an ionization chamber.
- Calibration of survey instruments and pocket dosimeters.
- Construction and calibration of a G.M. monitor.
- Calibration of a therapy level dosimeter.
- Calibration of TL phosphor & TLD reader and its use in dose distribution measurements.
- 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.
- Output measurement of a gamma chamber using Fricke dosimeter.
- Dose rate measurement of teletherapy machines using FBX dosimeter.
- Calibration of a TLD personnel monitoring badge and dose evaluation.
- Characteristics of a flow counter and beta activity measurement.
- Calibration of Gamma ray spectrometer [NaI(Tl), HPGe] and identification of unknown sources using multichannel analyser.

### ***Course Outcomes:***

- Students will gain hands-on experience in radiation spectroscopy, radiation detectors used in personnel and environmental dosimetry and radioanalysis of various samples.

## 11–PHYS26–625–P: MEDICAL PHYSICS LABORATORY – II (112 Lab hours)

**Coordinators: Mr. Lalatendu Mishra and Mr. Rakesh Kumar Bhatta**  
**Emails: [lalatendu.mishra81@niser.ac.in](mailto:lalatendu.mishra81@niser.ac.in) and [rakeshbhatta@niser.ac.in](mailto:rakeshbhatta@niser.ac.in)**

### *Course Details:*

- Calibration and use of alanine dosimeter using ESR technique.
- Preparation and standardization of unsealed sources.
- Quality assurance of a diagnostic X-ray machine.
- Evaluation of characteristics of a radiographic image.
- Study and calibration of thyroid uptake measurement unit.
- Dose output measurement of photon ( $^{60}\text{Co}$  gamma rays and high energy X-rays) beams used in radiotherapy treatment.
- Dose output measurement of electron beams used in radiotherapy treatment.
- Determination of percentage depth dose of photon and electron beams.
- Integrity check and calibration of low activity brachytherapy sources.
- AKS/ RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionisation chambers.
- In-phantom dosimetry of a brachytherapy source.
- Familiarisation with treatment planning procedure using a computerised radiotherapy treatment planning system.
- Survey of a radioisotope laboratory and study of surface and air contamination.
- Absorption and backscattering of gamma rays - Determination of HVT.
- Radiation protection survey of teletherapy installations.
- Radiation protection survey of diagnostic radiology installations

### *Course Outcomes:*

- Students will gain hands-on experience in radiation dosimetry, treatment planning, various QA aspects of therapy and imaging devices.