**M. Sc. Medical Physics**

**Syllabus**

**(With effect from the academic year 2023- 2024 onwards)**

**Program Code: MPHA**



**DEPARTMENT OF MEDICAL PHYSICS**

**SCHOOL OF PHYSICAL SCIENCES**

**BHARATHIAR UNIVERSITY**

**COIMBATORE 641 046, INDIA**

**(A State University, Accredited with “A++“ Grade by NAAC and 21st Rank among Indian Universities by MHRD-NIRF)**

**DEPARTMENT OF MEDICAL PHYSICS**

**SCHOOL OF PHYSICAL SCIENCES**

**BHARATHIAR UNIVERSITY, COIMBATORE 641046**

**VISION**

To produce professionally competent Medical Physicists and Atomic Energy Regulatory Board (AERB), Mumbai, Government of India, certified Medical Radiological Safety Officers (MRSOs) to the nation through effective teaching along with clinical exposure and translational research programs.

**MISSION**

* Train Medical Physics professionals to ensure utmost quality patient care.
* Provide excellent learning opportunities and educate in a variety of Medical Physics oriented disciplines including radiology, radiation oncology, nuclear medicine and radiobiology.
* Provide outstanding training in Medical Physics service for the safe and effective delivery of cutting edge radiotherapy treatments and medical imaging at par with International standards.
* Produce professionally competent Medical Physicists who can adopt in the Health Industry environment as well.
* Develop better methods and technologies for the personalized diagnosis and treatment of cancer disease focusing on radiation based approaches in medical imaging, radiation oncology, and image guided intervention.

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| **Program Educational Objectives (PEOs)** | |
| On completion of M.Sc., Medical Physics program, the students are expected to: | |
| PEO1 | Demonstrate the Physics, Biological and Safety aspects of Diagnostic radiology, External Beam Radiotherapy, Brachytherapy, Radiation Detection, Radiation Dosimetry, Advanced Radiotherapy Techniques and Nuclear Medicine for effective treatment of patients. |
| PEO2 | Learn step by step quality assurance/quality control procedures in medical imaging equipment and Radiation Oncology. |
| PEO3 | Categorize proper application of dosimetry and its instruments in medical imaging, and radiation dose delivery for Radiation Oncology. |
| PEO4 | Perform the applicators insertion of radioactive implants directly into the tissue during Brachytherapy. |
| PEO5 | Be prepared as effective RSO to meet the regulatory requirements in radiation  medicine for patient, personnel and public. |
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| **Program Specific Outcomes (PSOs)** | |
| After the successful completion of M.Sc. Medical Physics program, the students are  expected to: | |
| PSO1 | Disseminate their knowledge acquired through the state-of-the art radio  therapeutic techniques and medical imaging for providing and ensuring safety treatment for patients and integrate with the team/ leadership. |
| PSO2 | Achieve continuous improvement as medical physicist/radiation safety officers in their professional career and advanced technologies in pace with the developments in health care. |
| PSO3 | Be effective educators/trainers in their respective discipline. |
| PSO4 | Invent new technology in the field of Radiation Oncology and Imaging. |
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| **Program Outcomes (POs)** | |
| On successful completion of the M. Sc. Medical Physics program, the students are  expected to: | |
| PO1 | Have basic knowledge in Atomic Physics, Nuclear Physics, Solid State Physics,  Ionizing and Non-Ionizing Radiation Physics. |
| PO2 | Understand the Applied Mathematics in Radiation Sciences. |
| PO3 | Have domain knowledge in electronic components, computing skills using  MATLAB, MATHEMATICA, and STATISTICA and analyze the results obtained in radioactive counting, medical imaging or therapy. |
| PO4 | Gain skills on clinical aspects of radiation oncology with necessary knowledge in  anatomy, pathology, site specific signs, symptoms, diagnosis and management. |
| PO5 | Possess knowledge on Radiation Physics, Diagnostic radiology, External beam Radiotherapy, Brachytherapy, Radiation Detection, Radiation Dosimetry, Advanced Radiotherapy Techniques, Radiation Biology, and Radiation Safety as  per National as well as International regulatory agencies. |
| PO6 | Exhibit skills in handling GM counter based instruments, Gamma ray spectrometer,  analyze the sources, and determine linear and mass attenuation of sources, optically stimulated luminescence dosimetry. |
| PO7 | Have hands-on experience with Treatment Planning System, LINAC, and QA tools. |
| PO8 | Understand the issues of managing radiation safety programme as stipulated by  regulatory bodies to become a Radiological Safety Officer (RSO). |
| PO9 | Distinguish imaging techniques based on the demonstration of live blood perfusion imaging in nuclear medicine through PET-CT, SPECT and Gamma  Camera. |
| PO10 | Have hands-on experience to handle Radiation Physics, Radiology, Radiotherapy, Nuclear Medicine procedures and experiments. Ability to do research in Medical Physics and allied areas. |
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## BHARATHIAR UNIVERSITY, COIMBATORE 641 046

**M. Sc. Medical Physics Curriculum (University Department)**

*(For the students admitted during the academic year 2023 – 24 onwards)*

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| **FIRST SEMESTER** | | | | | | |
| **Course Components** | **Name of the Course** | **Industry hrs/ wk** | **CREDITS** | **Exam Hr/ Month** | **MAX MARKS** | |
| **CIA** | **External** |
| Core-1 | [Radiological Physics](file:///C:\Users\medical%20physics\Desktop\BoS%202023\C1-%20Radiological%20Physics.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-2 | [Radiological Mathematics](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C2- Radiological Mathematics and Statistical Analysis.docx)  [and Statistical Analysis](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C2- Radiological Mathematics and Statistical Analysis.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-3 | [Radiation Detection and](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C3- Radiation Detection and Measurement.docx)  [Measurement](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C3- Radiation Detection and Measurement.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-4 | [Radiation Generators](file:///C:\Users\medical%20physics\Desktop\BoS%202023\C4-%20Radiation%20Generators.docx) | 0 | 4 | 3 | 25 | 75 |
| Elective-1 | [Electronics and Instrumentation](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E1-%20Electronics%20and%20instrumentation.docx) (or) [Non-Ionizing Radiation](C:\\Users\\medical physics\\Desktop\\BoS 2023\\E1- Non Ionizing Radiation Physics.docx)  [Physics](C:\\Users\\medical physics\\Desktop\\BoS 2023\\E1- Non Ionizing Radiation Physics.docx) | 0 | 3 | 3 | 25 | 75 |
| Elective-2 | [Atomic, Molecular, & Nuclear Physics](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E2-%20Atom%20Mole%20Nuclear%20Physics.docx) (or) [Biomedical](C:\\Users\\medical physics\\Desktop\\BoS 2023\\E2- Biomedical Instrumentation.docx)  [Instrumentation](C:\\Users\\medical physics\\Desktop\\BoS 2023\\E2- Biomedical Instrumentation.docx) | 0 | 3 | 3 | 25 | 75 |
| Core Practical-1 | [Radiation Instrumentation](C:\\Users\\medical physics\\Desktop\\BoS 2023\\CP1- Radiation Instrumentation Lab.docx)  [Lab](C:\\Users\\medical physics\\Desktop\\BoS 2023\\CP1- Radiation Instrumentation Lab.docx) | 0 | 3 | 3 | 25 | 75 |
| **Sub Total** | | **0** | **25** | **21** | **175** | **525** |
| SEC-1 | [Introduction to Anatomy and Physiology](file:///C:\Users\medical%20physics\Desktop\BoS%202023\SEC%201-%20Intro%20to%20A%20and%20P.docx) | - | 1 | - | 25 | - |
| **SECOND SEMESTER** | | | | | | |
| **Course Components** | **Name of the Course** | **Industry hrs/ wk** | **CREDITS** | **Exam Hr/ Month** | **MAX MARKS** | |
| **CIA** | **External** |
| Core-5 | [Medical Imaging](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C5- Medical Imaging Technology.docx)  [Technology](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C5- Medical Imaging Technology.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-6 | [External Beam Radiation](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C6- External Beam RT.docx)  [Therapy](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C6- External Beam RT.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-7 | [Radiation Biology](file:///C:\Users\medical%20physics\Desktop\BoS%202023\C7-%20Radiation%20Biology.docx) | 0 | 4 | 3 | 25 | 75 |
| Core-8 | [Nuclear Medicine](file:///C:\Users\medical%20physics\Desktop\BoS%202023\C8-%20Nuclear%20Medicine.docx) | 0 | 4 | 3 | 25 | 75 |
| Elective-3 | [Numerical and Computational techniques](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E3-%20Numerical%20and%20Computational%20techniques.docx) (or)  [Advances in Medical Physics](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E3-%20Advances%20in%20Medical%20Physics.docx) | 0 | 3 | 3 | 25 | 75 |
| Elective-4 | [Solid State Physics](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E3-%20Advances%20in%20Medical%20Physics.docx) (or)  [Biological Dosimetry](file:///C:\Users\medical%20physics\Desktop\BoS%202023\E4-%20Biological%20Dosimetry.docx) | 0 | 3 | 3 | 25 | 75 |
| Core Practical- 2 | [Medical Physics Lab I](file:///C:\Users\medical%20physics\Desktop\BoS%202023\CP2-%20Med%20Physics%20Lab%20I.docx) | 0 | 3 | 3 | 25 | 75 |
| **Sub Total** | | **0** | **25** | **21** | **175** | **525** |
| B2- SEC 1 | [Summer Training](file:///C:\Users\medical%20physics\Desktop\BoS%202023\Summer%20training.docx) | - | 2 | - | 50 | - |
| SEC-2 | Online course from MOOC/ SWAYAM/ NPTEL/ Coursera/ e-Pataskala etc., | - | 2 | - | - | - |
| **Note:**   1. Summer Training will be carried out during the summer vacation of the first year and credits will be included in the Third Semester Marks Statement. 2. Online course (MATHLAB related course may be preferred) can be completed at any time before completion of the programme and credits will be included in the Fourth Semester Marks Statement. However, it is recommended to complete it during the first year of the programme. 3. SEC- Skill Enhancement Course | | | | | | |
| **THIRD SEMESTER** | | | | | | |
| **Course Components** | **Name of the Course** | **Industry hrs/ wk** | **CREDITS** | **Exam Hr/ Month** | **MAX MARKS** | |
| **CIA** | **External** |
| Core-9 | [Applied Anatomy and](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C9- Applied Anatomy and Physiology.docx)  [Physiology](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C9- Applied Anatomy and Physiology.docx) | 4 | 4 | 3 | 25 | 75 |
| Core-10 | [Radiation Dosimetry and](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C10- Radiation dosimetry and standardization.docx)  [Standardization](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C10- Radiation dosimetry and standardization.docx) | 3 | 5 | 3 | 25 | 75 |
| Core-11 | [Recent advances in](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C11- Recent advances in RT.docx)  [Radiotherapy](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C11- Recent advances in RT.docx) | 4 | 4 | 3 | 25 | 75 |
| Core-12 | [Radiation Hazards](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C12- Radiation Hazards Evaluation & Control.docx)  [Evaluation and Control](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C12- Radiation Hazards Evaluation & Control.docx) | 3 | 5 | 3 | 25 | 75 |
| Core-13 | [Advanced Radiation](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C13- Advanced Radiation Dosimetry.docx)  [Dosimetry](C:\\Users\\medical physics\\Desktop\\BoS 2023\\C13- Advanced Radiation Dosimetry.docx) | 4 | 4 | 3 | 25 | 75 |
| Core Practical- 3 | [Medical Physics Lab II](file:///C:\Users\medical%20physics\Desktop\BoS%202023\CP3-%20Med%20Physics%20Lab%202.docx) | 5 | 3 | 3 | 25 | 75 |
| **Sub Total** | | **23** | **25** | **18** | **150** | **450** |
| **FOURTH SEMESTER** | | | | | | |
| **Course Components** | **Name of the Course** | **Industry hrs/ wk** | **CREDITS** | **Exam Hr/ Month** | **MAX MARKS** | |
| **CIA** | **External** |
| B2- SEC 2 | [Project](file:///C:\Users\medical%20physics\Desktop\BoS%202023\Project.docx) | - | 7 | - | 25 | 75 |
| SEC-3 | [Tutorials in Medical Physics](file:///C:\Users\medical%20physics\Desktop\BoS%202023\SEC%203-%20Tutorial.docx) | - | 2 | - | 50 | - |
| SEC-4 | [Medical Radiological Safety Officer (MRSO) Training](file:///C:\Users\medical%20physics\Desktop\BoS%202023\SEC%204-%20MRSO%20Training.docx) | - | 2 | - | 50 | - |
| **Sub Total** | | **-** | **11** | **-** | **125** | **75** |
| **Total** | | **-** | **91** | **-** | **-** | **-** |

**DISTRIBUTION OF MARKS**

**A. THEORY**

1. **Continuous Internal Assessment (CIA)**

Internal Test (Average of best two test performance) : 10 Marks

Model Examination : 5 Marks

Assignment (Average of the two submitted) : 5 Marks

Seminar, Quiz and e-assessment : 5 Marks

**Total : 25 Marks**

2. **End Semester Examination : 75 Marks**

Pass Mark required in End Semester Examination : 37.5 Marks

Marks (CIA + Semester) required for earning the credits : 50 Marks

**B. LABORATORY**

1. **Continuous Internal Assessment (CIA)**

Average of marks awarded for the experiments done during regular Laboratory hours : 25 Marks

2. Final Comprehensive Examination

For the experiments carried out during the final examination : 65 Marks

Marks awarded for the record note book : 10 Marks

Total : 100 Marks

Marks required for earning the credits : 50 Marks

**C. PROJECT**

Continuous Internal Assessment (CIA) : 30

Evaluation of the Project report (External examiner and Faculty in-charge)

: 40

Viva Voce examination (External Examiner and Faculty in-charge)

: 30

Total : 100 Marks

Marks required for earning the credits : 50 Marks

**QUESTION PATTERN**

**Title:** \_\_\_\_\_\_\_\_

**Time: 3 hours Max. Marks = 75**

**PART A (10 Questions x 1 Mark = 10 Marks)**

**Answer all questions- Choose the best Answer/ Fill in the Blanks/ True or False**

Note: Two questions from each unit.

1. \_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_

6. \_\_\_\_\_\_\_\_

7. \_\_\_\_\_\_\_\_

8. \_\_\_\_\_\_\_\_

9. \_\_\_\_\_\_\_\_

10. \_\_\_\_\_\_\_\_

**PART B (5 Questions x 5 Marks = 25 Marks)**

**Answer all questions having internal choice (Either or type)**

Note: At least one question from each unit.

Weightage of the unit may also be taken into consideration.

11. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

12. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

13. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

14. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

15. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

**PART C (5 Questions x 8 Marks = 40 Marks)**

**Answer all questions having internal choice (Either or type)**

Note: At least one question from each unit.

Weightage of the unit may also be taken into consideration.

16. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

17. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

18. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

19. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

20. (a) \_\_\_\_\_\_\_\_

(OR)

(b) \_\_\_\_\_\_\_\_

**SEMESTER I**

|  |  |
| --- | --- |
| **Core 1- RADIOLOGICAL PHYSICS** | **I Year – I Semester** |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 13A | **RADIOLOGICAL PHYSICS** | Core | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| Atomic and Nuclear Physics |
| **Learning Objectives** |
| * Study electromagnetic spectrum, radiation sources, types and its properties * Study radiation Quantities and Units used in the industry * Understand the interaction of directly and indirectly ionizing radiation with matter and its effects. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Electromagnetic Spectrum** | Production, properties and classification of electromagnetic radiation- Different sources of radiation - radio waves, microwaves, infrared, visible, ultra violet radiation, X and Gamma rays-production, physical properties and their interaction with tissues. |
| **UNIT II:**  **Radioactivity** | Radioactivity - General properties of alpha, beta and gamma rays - Laws of radioactivity - Half life and Average Life- Laws of successive transformations - Natural radioactive series - Radioactive equilibrium - Alpha ray spectra - Beta ray spectra - Gamma emission – Electron capture - Internal conversion - Nuclear isomerism - Artificial radioactivity. |
| **UNIT III:**  **Ionizing Radiation Quantities and Units** | Radiometric quantities: Activity, exposure, Particle flux, fluence, fluence rate– Energy flux and energy fluence.  Interaction Quantities: Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, Stopping power, Mass Stopping Power and LET.  Dosimetric Quantities: Exposure, Absorbed Dose, Kerma, Terma, Charged particle equilibrium (CPE) – Relationship between Kerma, absorbed dose and exposure under CPE - Radiation chemical yield - W value.  Radioactivity Units: Becquerel & Curie, exposure units - C/kg & Roentgen, Gray & Rad, Sievert & Rem. |
| **UNIT IV:**  **Interaction of indirectly ionizing radiation with Matter** | Interaction of electromagnetic radiation with Matter: Exponential attenuation - Thomson scattering - Photoelectric and Compton process and energy absorption - Pair production - Attenuation and mass energy absorption coefficients - Relative importance of various processes.  Interaction of neutrons with matter: Classification of neutrons, neutron sources, slow and fast neutron interactions, microscopic and macroscopic interaction cross section, charged particle emission, - radiative capture and its significance in radiation dose to humans – elastic and inelastic scattering- Neutron induced nuclear reactions- neutron induced activation –fission – Neutron attenuation. |
| **UNIT V:**  **Interaction of directly ionizing particles with matter** | Interaction of charged particles with matter: Classical theory of inelastic collisions with atomic electrons - Energy loss per ion pair by primary and secondary ionization - Dependence of collision energy losses on the physical and chemical state of the absorber - Cerenkov radiation - Electron absorption process – Scattering, Excitation and Ionization - Radiative collision – Bremmstrahlung- Continuous slowing down approximation (CSDA) - transmission and depth dependence methods - Range energy relation - Back scattering. Interaction of heavy charged particles: Energy loss by collision - Range energy relation - Bragg curve – Spread out Bragg Peak (SOBP) - Specific ionization - Bethe Bloch Formula. |
| **UNIT VI:**  **Contemporary Issues** | https://www.youtube.com/watch?v=p2rx8Qpw49w  https://www.youtube.com/watch?v=RzU8BZVN1BQ |
| **TEXT BOOKS** | 1. Radiation Physics in Radiology, Oliver R., Blackwell Science Ltd; 1st Edition (1966). 2. Radiation Physics for Medical Physicists, E.B.Podgarsak, Springer Verlag, 1st Edition (1996). |
| **REFERENCE BOOKS** | 1. The Physics of radiology, H.E.Johns and Cunningham, Charles C Thomas Publishers, 1st edition (1984). 2. Radiation Oncology Physics: Handbook for Teachers and Students, E.B.Podgarsak, IAEA,Vienna, 1st Edition (2005). |
| **WEB SOURCES** | 1. <https://nptel.ac.in/courses/115/102/115102017/> 2. <https://nptel.ac.in/courses/115/106/115106087/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Explain different types Electromagnetic Radiation and their sources/properties | K4 |
| **CO2** | Explain different types of Radiation, their sources/properties. | K4 |
| **CO3** | Remember Radiation Quantities and Units. | K1 |
| **CO4** | Analyze Physics aspects of Interaction of indirectly ionizing radiation with matter. | K3 |
| **CO5** | Understand interaction of directly ionizing radiation with matter and its effects inside a living object. | K3 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | M | M | M | M | M | M | M | M | M | M |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **Core 2- RADIOLOGICAL MATHEMATICS AND STATISTICAL**  **ANALYSIS** | **I YEAR - I SEMESTER** |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 13B | **RADIOLOGICAL MATHEMATICS AND STATISTICAL ANALYSIS** | Core | 0 | 4 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| **Mathematical Physics - UG level** |
| **Learning Objectives** |
| * To expose the students to learn the different types of probability, measures of central tendency and their mathematical properties * To Provide the correlation and regression analysis to find the relation between two sets of data. * To understand the methods of counting and their usage in medical fields |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Probability, Statistics and Measure of central tendency** | 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, and measures of central tendency-arithmetic mean, Mathematical properties of mean, median, mode, Geometrical mean, Harmonic Mean, Mathematical properties of Geometrical mean, Harmonic Mean, relationship among the averages, General limitation of average. |
| **UNIT II:**  **Measures of Variation** | Objectives of measuring Variation, Properties of a good measure of variation, Method of studying variation- The range, mean deviation, standard deviation/ root mean square deviation, Variance, Absolute and relative measures of variation, Coefficient of variation, Merits and limitations of standard deviation. Skewness, moments and kurtosis. |
| **UNIT III:**  **Correlation and Regression Analysis** | Correlation, Types of correlation, Methods of ascertaining correlation - Scatter diagram, Karl Pearson's coefficient, Rank method, merits and limitations of all methods, Regression, Difference between correlation and regression, Regression coefficient, calculation of regression coefficients. |
| **UNIT IV:**  **Counting statistics** | 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, applications of Bivariate distribution, Chi-Square distribution, F- distribution, t-distribution- overview of biostatistical tools- reference styles, reference manager, citation manager. |
| **UNIT V:**  **DIFFERENTIAL EQUATIONS** | 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 - Statistical aspects of Clinical study designs and clinical trial- Signal-to-noise ratio 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. Hypothesis testing and errors- Examples and exercises. |
| **UNIT VI:**  **PROFESSIONAL COMPONENTS** | Index numbers, Small sampling theory, and Interpretation of Data,  <https://nptel.ac.in/courses/111/104/111104073/> |
| **TEXT BOOKS** | 1. F. E. Croxton, Elementary statistics with applications in medicine and the biological sciences, Dover, New York, 1st Edition, 1959. 2. S.P.Gupta, Statistical methods, Sultan Chand & Sons Educational publishers, New Delhi 44th Edition, 2014 3. W. Band, Introduction to Mathematical Physics, Van Nostrand Reinhold Inc. U.S., 1st |
| **REFERENCE BOOKS** | 1. G. Dahlberg, Statistical Method of Medical &Biology students, G. Allen & Unwin Ltd, London,2nd Edition, 1948 2. S.P. Gupta, Statistical methods Sultan Chand & Sons, 2012 3. E. Kreyszig, 1983, Advanced Engineering Mathematics, Wiley Eastern, New Delhi, 4. D. G. Zill and M. R. Cullen, 2006, Advanced Engineering Mathematics, 3rd Ed. Narosa, New Delhi. 5. S. Lipschutz, 1987, Linear Algebra, Schaum's Series, McGraw - Hill, New York 3. E. Butkov, 1968, Mathematical Physics Addison - Wesley, Reading, Massachusetts. |
| **WEB SOURCES** | 1. <https://nptel.ac.in/courses/111/105/111105077/> 2. <https://www.coursera.org/lecture/basic-statistics/5-03-the-sampling-distribution-ejnZI> 3. https://swayam.gov.in/nd1\_noc19\_bt19/preview |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Choose the correct probability for medical treatment, and correct measure ofcentral tendency for practical applications | **K1, K2** |
| **CO2** | Apply the methods of deviations and distribution to set of data and measure the corresponding parameters from central tendency | **K2, K3** |
| **CO3** | Do an analysis of two sets of data and calculate unknown one from known set of data. | **K3,K4** |
| **CO4** | Apply the particular distribution function for particular sampling size | **K4, K5** |
| **CO5** | Gain adequate knowledge and working principle of the Gamma ray, Beta ray counting methods and medical statistics. | **K2, K5** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO3** | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 3 |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO2** | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 |
| **CO3** | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 3 |

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| **Core 3- RADIATION DETECTION AND MEASUREMENT** | **I Year – I Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 13C | **RADIATION DETECTION AND MEASUREMENT** | Core | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| Electronics and Instrumentation |
| **Learning Objectives** |
| * To understand the technical know- how of all the radiation detectors used for cancer diagnosis, treatment, and radiological safety. * To choose an appropriate detector for appropriate measurement. * To learn about the working of radiation instruments used in advanced radiation therapy. * To understand the applications and uses of radiation safety devices. * To understand the various factors behind the measurement of radiation and analysis of data. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Gas Filled Detectors** | Basic principles of radiation detection- Gas Filled detectors - Ionization chambers, - Theory and design - Construction of condenser type chambers and thimble chambers - Gas multiplication - Proportional and GM Counters – basic detection mechanism, types of radiation detected, mode of operation, different variants of detectors (e.g. sealed, flow type, high pressure, multi-wire, position sensitive) - Types of instruments which uses gas filled detectors – radiation dosimeters, survey meters, contamination monitors- Cylindrical, plane parallel, spherical and well-type ionization chambers, Extrapolation chamber- Dead time and recovery time. |
| **UNIT II:**  **Solid State Detectors** | Scintillation detectors: Advantages of scintillation detectors, properties of ideal scintillator, basic electronic blocks in scintillation detector setup. Radiation detection mechanism of organic and in- organic scintillators, Characteristics of organic and inorganic counters -types of scintillators for various applications.  Semiconductor detectors and its application for gamma spectrometry, Diode and MOSFET dosimeters - Chemical dosimeters- Radiographic Film: Components of radiographic film, principle of image formation on film, double and single emulsion film, sensitometric parameters of film (density, speed, latitude etc.) and Radio chromic films - Thermo luminescent Dosimeters (TLD) – Optically stimulated Luminescence dosimeters (OSLD) – Radiophoto luminescent dosimeters (RPLD).  Neutron Detectors: Slow Neutron Detection and Fast Neutron Detection methods- Nuclear track emulsions for fast neutrons - Solid State Nuclear track (SSNTD) detectors - Neutron detection by activation, BF3, 3He, Bubble detectors. Calorimeters - New Developments (direct ion storage (DIS), diamond detectors etc). |
| **UNIT III:**  **Radiation Dosimeters & Monitoring Instruments** | Dosimeters based on condenser chambers - Pocket chambers - Dosimeters based on current measurement - Different types of electrometers – MOSFET - Diode Detectors, Semi-conductor Detectors., Vibrating condenser and Varactor bridge types - Secondary standard therapy level dosimeters - Farmer type Dosimeters: Thimble chambers and Parallel-plate chambers - Properties of Farmer-type chambers like sensitivity, energy dependence, stem effect, and influence of temperature and pressure, bias voltage, direction dependence – reference and field-level chambers – small volume chambers for RFA -– Radiation field analyzer (RFA) - Radioisotope calibrator - Multipurpose dosimeter (used in Diagnostic Radiology) - Water phantom dosimetry systems - Brachytherapy dosimeters – well type chamber-Isotope calibrators-Thermo luminescent dosimeter readers for medical applications - Calibration and maintenance of dosimeters. |
| **UNIT IV:**  **Instruments for Personnel and Area Monitoring** | Instruments for personnel monitoring - TLD badge readers – Personnel Monitoring film densitometers – OSLD readers - Glass dosimeter readers – Working principle of Digital pocket dosimeters using solid state devices and GM counters.  Instruments for area monitoring: Portable and fixed area monitors, beta-gamma zone monitor, survey meters, Gamma area (Zone) alarm monitors –wide range survey instrument- Teletector, . Contamination monitoring instruments for portable contamination monitor, alpha, beta and gamma radiation detection- Laundry Monitors, Pocket Neutron Monitors, Teledose system.Hand and Foot monitors –Whole Body counter, Portal Monitors - Scintillation monitors for X and gamma radiations - Neutron area Monitors, Tissue equivalent survey meters - Flux meter and dose equivalent monitors - neutron personnel monitors- Properties of survey meters and personal monitors (Sensitivity, energy dependence, directional dependence,  discrimination between different types of radiation, Uncertainties in their measurements, etc. |
| **UNIT V:**  **Nuclear Medicine Instruments** | Instruments for counting and spectrometry - Portable counting systems for alpha and beta radiation - Gamma ray spectrometers –Single and Multichannel Analyser– HPGe- Liquid scintillation counting system (Organic/Inorganic)- RIA counters – Whole body counters - Air  Monitors for radioactive particulates and gases. |
| **UNIT VI:**  **Contemporary Issues** | 1. Ionisation Chambers & Proportional Counters - https://youtu.be/avvXftiyBEs 2. GM counter - https://youtu.be/jxY6RC52Cf0 3. Semi Conductor Detectors <https://youtu.be/c1boCCYs77Q> 4. Film Badge - https://youtu.be/eGymsO6Assc 5. TLD - <https://youtu.be/domGWQ-Jrzw> 6. OSLD - https://youtu.be/hPOXGYKtww4 7. Pocket Dosimeter - <https://youtu.be/iPesezYcL-o> 8. Neutron Bubble detector - https://youtu.be/teDejUPjdlM 9. Radiographic film - <https://youtu.be/0GIwERBJ2SU> 10. Radiochromic film - https://youtu.be/06kh1ILKDro 11. Area Monitoring device- Gamma Zone Monitor - <https://youtu.be/AA18OH1jHEY> 12. Hand and Foot Monitor - https://youtu.be/oP\_XTk6xYmk 13. Whole body counter - <https://youtu.be/fFsfIp9EY2E> 14. Multi Channel Analyzer - https://youtu.be/75EY30TwBHw 15. Gamma ray spectrometer - <https://youtu.be/hQ_gtJE4o7s> |
| **TEXT BOOKS** | 1. Glenn E Knoll, Radiation Detection and Measurement, Third Edition, John Wiley & Sons, Inc, 2000. 2. Nicholas Tsoulfanidis, Measurement and Detection of Radiation, 2nd Edition, Taylor and Francis, 1995. 3. Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices by [Lucio Cerrito](https://www.amazon.in/s/ref%3Ddp_byline_sr_book_1?ie=UTF8&field-author=Lucio%2BCerrito&search-alias=stripbooks) (Author), May 2017. |
| **REFERENCE BOOKS** | 1. Radiation Oncology Physics: A handbook for teachers and students, International Atomic Energy Agency (IAEA), 2005. 2. Fabio Sauli, Gaseous Radiation Detectors: Fundamentals and applications, Cambridge University press, 2014. 3. Student Solutions Manual to accompany Radiation Detection and Measurement, by Glenn F. Knoll , July 2012. |
| **WEB SOURCES** | 1. [https://ocw.mit.edu/courses/nuclear-engineering/22-01-introduction-to-nuclear-engineering-and- ionizing-radiation-fall-2016/lecture-videos/practical-radiation-counting-experiments2014solid- angle-count-rates-uncertainty-and-hands-on-gamma-counting-and-nuclear-activation-analysis/](https://ocw.mit.edu/courses/nuclear-engineering/22-01-introduction-to-nuclear-engineering-and-%20ionizing-radiation-fall-2016/lecture-videos/practical-radiation-counting-experiments2014solid-%20angle-count-rates-uncertainty-and-hands-on-gamma-counting-and-nuclear-activation-analysis/) 2. <https://ocw.mit.edu/courses/nuclear-engineering/22-01-introduction-to-nuclear-engineering-and-ionizing-radiation-fall-2016/lecture-videos/radiation-utilizing-technology/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Update fundamental knowledge, technological advancements and potential  applications of radiation detectors. | K3 |
| **CO2** | Choose appropriate detectors to reduce the errors in treatment. | **K3** |
| **CO3** | Learn about radiation instruments available for research and the scope for further research. | **K2** |
| **CO4** | Acquire knowledge on radiation safety and personal monitoring devices. | **K3** |
| **CO5** | Measure radiation precisely and interpret their results accurately with statistical significance. | **K3** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | M | L | M | L | S | S | L | M | M | S |
| **CO2** | M | L | M | L | S | S | L | M | M | S |
| **CO3** | M | L | M | L | S | S | L | M | M | S |
| **CO4** | M | L | M | L | S | S | L | M | M | S |
| **CO5** | M | L | M | L | S | S | L | M | M | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 1 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO2** | 2 | 1 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO3** | 2 | 1 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO4** | 2 | 1 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO5** | 2 | 1 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 3 |

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| **Core 4- RADIATION GENERATORS** | **I Year- I Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 13D | **RADIATION GENERATORS** | Core | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| Physics - Graduate level |
| **Learning Objectives** |
| * To learn the construction and working of different types of particle accelerators. * To learn the construction of X-ray generator used in Diagnostic radiology. * To learn the construction and working of various equipments used in external beam therapy * To learn the construction and working of various equipments used in Brachytherapy * To learn the radioisotopes produced from the above equipment and their medical applications |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **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 - Rating of tubes –standard exposure charts, Limitations on loading Safety devices in X-ray tubes - Insulation and cooling of X-ray tubes –Design requirements for x-ray equipment, Faults detection in X-ray equipment such as pitting of anode, filament evaporation etc., - Types of x-ray units (Fixed radiography, CT, Interventional radiology, C-Arm, Mammography, Bone Mineral Densitometer, dental X-ray units etc.,). Filtration in the x-ray machines-inherent, target and added filters. |
| **UNIT II:**  **Particle Accelerators** | Particle accelerators for industrial, medical and research applications - The Resonant transformer Cascade generator - Van De Graff Generator - Pelletron - Betatron - Synchro- Cyclotron- Linear Accelerator - Klystron and magnetron - Travelling and Standing Wave Acceleration – Microtron -Electron Synchrotron-Proton synchrotron- Hadron (proton/carbon ion) accelerators.  Working principle of Cyclotron and charged particle accelerators, Applications of cyclotrons in medicine, Types of Cyclotrons: self-shielded and unshielded (in-bunker) and locally shielded. Beam transport systems - Beam delivery systems- Energy slits – degrader - Ridge filter - Range Shifter -Uniform and Pencil beam scanning systems-beam dump- Auxiliary equipment and their safety significance: vacuum pumps, RF-power, magnet power supply; cooling system, control software and programs used for medical cyclotron operation. |
| **UNIT III:**  **External Beam Therapy (EBRT) Equipment** | Working principles of Telecobalt, Gammaknife, Linear Accelerator, Cyber Knife, Tomotherapy, Intra Operative Radiotherapy & Proton/carbon ion Therapy. Components of beam delivery mechanism such as target, flattening filter, scattering foil, bending magnet, monitor chamber, Collimator jaws, MLC, micro MLC and other systems specific to various types of equipment. Safety interlocks in beam delivery process. Source design and classification- beam collimation and penumbra - trimmers and breast cones used in telecobalt unit. Wedges, electron applicators, cone beam CT, couch, sagittal lasers. |
| **UNIT IV:**  **Brachytherapy Equipment** | Definition and classification of brachytherapy techniques - surface mould, intracavitary, interstitial and intraluminal techniques. Dose rate considerations and classification of brachytherapy techniques - Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR). After loading techniques - Advantages and disadvantages of manual and remote after loading techniques. Catheters, safety shields for wire cutting in LDR. |
| **UNIT V:**  **Radiation Sources and their Medical Applications** | Radiation sources - Natural and artificial radioactive sources - Large scale production of isotopes Reactor produced isotopes ( 60Co, 192Ir, 99Mo etc.,) - Cyclotron produced isotopes (18F, 13N, 15O, 11C)- Fission products (137Cs,99Mo,131I,90Sr)–Teletherapy sources– Requirement for brachytherapy sources - Description of radium and radium substitutes - 137Cs, 60Co, 192Ir, 125I and other commonly used brachytherapy sources. Beta ray applicators – ophthalmic applicators (90Sr,125I, 106Ru etc.,) Thermal and fast neutron sources (241Am-Be, 252Cf etc.,)- Gold seeds, Tantalum wire, Preparation of tracers and labelled compounds and Preparation of ratio colloids. |
| **UNIT VI:**  **Professional Components** | 1. <https://www.aapm.org/meetings/2010AM/documents/biggs2.pdf> 2. <http://www-naweb.iaea.org/nahu/DMRP/documents/Chapter5.pdf> |
| **TEXT BOOKS** | 1. F. M. Khan, The Physics of Radiation therapy, 3rd Edition, LIppincott Williams &Wikins, Philadelphia, 2003 2. H. E. Johns and J. R. Cunningham, Physics of Radiology, 4thEdition, (Charles C Thomas Pub.Ltd,. 1983. 3. W. R. Hendee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003. |
| **REFERENCE BOOKS** | 1. Thomas S. Curry, James E. Dowdey, andRobert E. Murry, Christensen's Physics of Diagnostic Radiology, 4th Edition, 1990. 2. E. J. N. Wilson, An Introduction to Particle Accelerators, 1st Edition, Oxford, 2001. |
| **WEB SOURCES** | <https://radiologykey.com/clinical-radiation-generators/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Knew about the different types of particle accelerators and their medical  applications. | K2 |
| **CO2** | Learnt to operate the X-ray generator used in Diagnostic radiology | K3 |
| **CO3** | Learnt to operate the equipment used in external beam therapy | K3 |
| **CO4** | Learnt to operate the equipment used in Brachytherapy | K3 |
| **CO5** | Know about the radioisotopes produced from particle accelerators for external  beam therapy and Brachytherapy | K2 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES:**

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | L | L | L | L | L | L | L | L |
| **CO2** | S | M | L | L | L | L | L | L | L | L |
| **CO3** | S | M | L | L | L | L | L | L | L | L |
| **CO4** | S | M | L | L | L | L | L | L | L | L |
| **CO5** | S | M | L | L | L | L | L | L | L | L |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

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| **Elective 1- ELECTRONICS AND INSTRUMENTATION** | **I YEAR - I SEMESTER** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 1EA | **ELECTRONICS AND INSTRUMENTATION** | Elective | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| **Semiconductor Physics, analog electronics - UG level** |
| **Learning Objectives** |
| * Give the fundamental concepts of p-n junction, diode, transistors and amplifiers. * To study the boolean equations and data processing circuits, and understand the different types of Flip-flops, and Counters. * To provide fundamental knowledge of electric accessories for X-Ray tubes. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Diode and Transistor** | Semiconductors, Bonds in semiconductor, Classification of semiconductors, semiconductor diode - Half-wave rectifier, Centre -Tap full-wave rectifier, Full wave bridge rectifier, Bipolar junction transistors - CB connection and characteristics CE connection and characteristics - JFET – MOSFET |
| **UNIT II:**  **Operational amplifier** | Integrated Circuits - Operational amplifiers (Op- Amp) and their characteristics, the ideal op Amp - Common mode rejection ratio (CMMR), Differential Amplifier - Operational amplifier systems – Op-Amp Applications -Addition, subtraction, Integration and Differentiation - Voltage-to- current converter, Current-to-voltage converter, Logarithmic amplifier. |
| **UNIT III:**  **Digital Electronics - Data Processing** | Logic gates - Boolean algebra - Boolean laws – De-Morgans theorem - Sum-of-Products method – Product of sum method - Multiplexers, 16 - 1 Multiplexer, Nibble multiplexer, De-multiplexer, 1 - 16 de-mutiplexer circuits - Decoder, BCD to Decimal decoders 1 of 16 decoder, Seven segment decoders - Encoder, Decimal to BCD encoder |
| **UNIT IV:**  **Digital Electronics - Flip-flops and counters** | Types of Flip Flops: RS, Clocked RS, D-Flip Flop, Edge-triggered D Flip flop – J K Flip flop - Master slave JK Flip flop, Counters: Ripple counters - up, down and up-down ripple counters - Asynchronous and synchronous counters |
| **UNIT V:**  **Diagnostic X-ray units** | Filament and high voltage transformers - High voltage circuits - Condenser discharge apparatus - Three phase apparatus - Voltage doubling circuits - Current and voltage stabilizers - Automatic exposure control - Automatic Brightness Control- Measuring instruments for Measurement of kV and mA - timers - Control Panels - Complete X-ray circuit - Image intensifiers and flat panel detectors - Computed Radiography and Digital Radiography Systems - Modern Trends |
| **UNIT VI:**  **Professional Components** | Expert lectures, online seminars – webinars  Building Blocks, Design of control unit, Programming language |
| **TEXT BOOKS** | 1. A.P. Malvino and D.P. Leach, Digital Principles and Applications, Tata McGraw-Hill 2. Jacob Millman, and Christos C. Halkias, Integrated Electronics Mcgraw- Hill Kogakusha. LTD 3. A.B. Bhattacharya, Electronic Principles and Applications, New Central   Book Agency,Kolkata, 1st Edition, 2007 |
| **REFERENCE BOOKS** | 1. Santanue Chattopadhyay, A text book of Electronics, New Central Book Agency, Kolkata,2006 2. Chinmoy Saha, A. Halder, and D. Ganguly, Basic Electronics: Principles and Applications, 1st Edition, 2018 |
| **WEB SOURCES** | 1. <https://nptel.ac.in/courses/117/107/117107095/> 2. <https://swayam.gov.in/nd1_noc20_ee32/preview> 3. <https://nptel.ac.in/courses/108/105/108105132/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Understand the usage of various semiconductor based components/devices for constructing electronic circuits | K1, K3 |
| **CO2** | Understand the important of Op-amp IC and its applications | **K2, K3** |
| **CO3** | Know functioning of various logic gates and fundamentals of digital electronics. | **K3,K4** |
| **CO4** | Capable of how the digital data is stored and counted in CPU using flip-flops in counters | **K4, K5** |
| **CO5** | Analyze the concepts, and various electric accessories of X-ray tubes, moreover X-ray generators for therapeutic applications | **K4, K5** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 12 | 2 | 3 | 3 | 2 | 2 | 3 |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO3** | 1 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 |

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| **Elective 1- NON-IONIZING RADIATION PHYSICS** | **I YEAR - I SEMESTER** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 1EB | **NON-IONIZING RADIATION PHYSICS** | Elective | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| **Atomic, Molecular, and Nuclear Physics - UG level** |
| **Learning Objectives** |
| * To know the fundamentals of Non-ionising Radiation (NIR) physics, Various Tissue Optics techniques. * To understand Mediphotonics and its applications. * To evaluate Radio Frequency and Microwave applications |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Fundamentals of Non-ionizing Radiation physics** | Elctromagnetic spectrum - Different sources of Non- Ionizing radiation-their physical; properties- first law of photochemistry-Law of reciprocity- - Electrical Impedance and Biological Impedance- Principle and theory of thermography – applications |
| **UNIT II:**  **Applications of optical radiation** | Introduction to optical radiations - UV, visible and IR sources - Lasers: Theory and mechanism- Lasers in Surgery - fluence measurement from optical sources - Optical properties of tissues – interaction of laser radiation with tissues– photo thermal -photochemical – photo ablation – Electro mechanical effect. |
| **UNIT III:**  **Lasers in Medicine** | Lasers in medicine-applications of Ultrafast pulsed Lasers -Lasers in dermatology, oncology and cell biology - Lasers in blood flow measurement - Fiber optics in medicine - Hazards of lasers and their safety measures. |
| **UNIT IV:**  **Radio Frequency and Microwave in Medicine** | Production and properties- interaction mechanism of RF and mirocwaves with biological systems: Thermal and non-thermal effects on whole body, lens and cardiovascular systems- tissue characterization and Hyperthermia and other applications. |
| **UNIT V:**  **Diagnostic X-ray units** | Filament and high voltage transformers - High voltage circuits - Condenser discharge apparatus - Three phase apparatus - Voltage doubling circuits - Current and voltage stabilizers - Automatic exposure control - Automatic Brightness Control- Measuring instruments for Measurement of kV and mA - timers - Control Panels - Complete X-ray circuit - Image intensifiers and flat panel detectors - Computed Radiography and Digital Radiography Systems - Modern Trends |
| **UNIT VI:**  **Professional Components** | 1. https://www.youtube.com/watch?v=HxYcI7uXuhA 2. https://www.youtube.com/watch?v=q2CrDNJQMc0 3. <http://www.digimat.in/nptel/courses/video/108105091/L04.html> |
| **TEXT BOOKS** | 1. Harry Moseley, Hospital Physicists' Association, Non-ionizing radiation: microwaves, ultraviolet, and laser radiation, A. Hilger, in collaboration with the Hospital Physicists' Association, 1988. 2. J. R. Greening, Medical Physics, North Holland Publishing Co., New York, 1999. |
| **REFERENCE BOOKS** | 1. R. Pratesi and C. A. Sacchi, Lasers in Photo medicine and Photobiology, Springer Verlag, West Germany, 1980. 2. J. P. Woodcock, Ultrasonic, Medical Physics Handbook series 1, Adam Hilger, Bristol, 2002. |
| **WEB SOURCES** | 1. <https://spie.org/news/spie-professional-magazine-archive/2011-january/lasers-in-medicine?SSO=1> 2. <https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Explain different types of Non-ionizing radiation and its properties and applications. | K1, K2 |
| **CO2** | Explain different Application of optical properties of NIR in tissues. | **K1, K2** |
| **CO3** | Understand the applications of Laser in Medicine. | **K2,K3** |
| **CO4** | Understand the applications of Radio Frequency and Microwave in Medicine. | **K3, K4** |
| **CO5** | Understand the applications of Ultrasound in Medicine. | **K4** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

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| **Elective 2- ATOMIC, MOLECULAR AND NUCLEAR PHYSICS** | **I Year- I Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 1EC | **ATOMIC, MOLECULAR AND NUCLEAR PHYSICS** | Elective | 3 | 0 | 0 | 3 | 0 | 100 |

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| --- |
| **Pre-Requisites** |
| Particle Physics |
| **Learning Objectives** |
| * Study the physics of various atomic models and their relative merits/demerits in explaining the properties of matter. * Understand physics of absorption and emission spectra, and the action of LASER, * Know nature of nuclear force and the basic characteristics of nuclei. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Atomic Physics** | Thomson’s Model - Rutherford Model – Bohr’s Model of Hydrogen atom, Limitations – Sommerfeld model – Bohr’s Correspondence Principle – Davison- Germer Experiment – Uncertainity Principle – Phase and Group velocities - Hydrogen Spectrum– Stern-Gerlach Experiment – Electron spin, Gyromagnetic Ratio – Spin-Orbit Interaction (Fine Structure). |
| **UNIT II:**  **Molecular Spectra** | Angular Momentum; L-S Coupling, J-J Coupling, Hund Rules – Zeeman Effect (Normal & Anomalous) – Characteristic X-ray Spectrum –Raman Effect: Theory, Characteristics and Applications – Absorption and emission of radiation by Matter – Einstein’s coefficients, Conditions for stimulated emission – Methods of Population Inversion- Components of laser–Typical Lasers: Ruby, He-Ne. |
| **UNIT III:**  **Properties of Nuclei and Nuclear Force** | Isotopes, Isobars, Isotones and Mirror Nuclei – Nuclear Density and Binding Energy – Binding Energy and Stability – Mass Defect and Packing Fraction – Nuclear Size, Spin, Energy Levels and Magnetic Moment – Nuclear Parity – Nuclear Forces – Ground State of Deuteron – Exchange Forces; Yukawa Model and estimation of Mass of Meson. |
| **UNIT IV:**  **Nuclear Models** | Liquid Drop Model; Semi-empirical Mass Formula – Mass Parabola: Prediction of Stability against β-decay – Spontaneous Fission: Stability Limits – Potential Barriers for Fission –Stability Limits – Shell Model; Salient features – Predictions of Shell Model – Collective Model |
| **UNIT V:**  **Radioactive Disintegration and Nuclear Reactions** | Radioactivity – α-particles; Geiger-Nuttal Law, Gamow Theory of α-decay, β-decay: Determination of β-energy, γ-rays; Origin, γ-ray Spectrum, Interaction with Matter – Energy of γ-rays – Nuclear reactions; Types, Conservation Laws – Q-Values, Q-equation and its Solution – Nuclear Reactor; Construction and types – Nuclear Fusion; Natural Fusion, Controlled Fusion |
| **UNIT VI:**  **Contemporary Issues** | Expert Lectures, Online Seminars - Webinars  <https://www.youtube.com/watch?v=bukjtmM2djU> |

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| **TEXT BOOKS** | 1. A.B. Gupta, Modern Atomic and Nuclear Physics, Books and Allied (P) Ltd. 2nd Edition,2012. 2. S. B. Patel, Nuclear Physics: An Introduction, New Age International, New Delhi, 2nd Edition, 2011. 3. D.C. Tayal, Nuclear Physics., Himalaya Publishing House, 2nd Edition, 2009. |
| **REFERENCE BOOKS** | 1. S. N. Ghoshal, S. Chand, Nuclear Physics 1st Edition, 1997 2. D.C. Tayal, Nuclear Physics., Himalaya Publishing House, 2nd Edition, 2009. |
| **WEB SOURCES** | 1. https://nptel.ac.in/courses/115/101/115101003/ 2. https://nptel.ac.in/courses/115/103/115103101/ 3. https://nptel.ac.in/courses/115/102/115102017/ |

COURSE OUTCOMES:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Know about various atomic models | K1 |
| **CO2** | Understand the significance of Spectra and lasers in exploring the material  properties. | **K2** |
| **CO3** | Analyze the nature of nuclear force | **K4** |
| **CO4** | Understand the various nuclear models | **K2** |
| **CO5** | Understand how to exploit nuclear energy produced through various nuclear reactions. | **K2** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO2** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO3** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO4** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO5** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO2** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO3** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO4** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO5** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |

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| **Elective 2- BIOMEDICAL INSTRUMENTATION** | **I Year- I Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 1ED | **BIOMEDICAL INSTRUMENTATION** | **Elective** | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| Basics electronics and instrumentation |
| **Learning Objectives** |
| * Understand the different potentials and equivalent circuits for medical treatment. * Know the fundamental concepts, functioning, applications of physiological devices and the importance of clinical and operation theatre equipment. * Provide the knowledge of telemetry system, protection, and modern technologies used in the biomedical instrumentation. |

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| **UNITS** | | **Course Details** |
| **UNIT I:**  **Bioelectric Signal Recording** | | Bioelectric potentials – resting and action potentials – half cell potentials- Surface, needle and micro electrodes, electrical equivalent circuits |
| **UNIT II:**  **Physiological Assist Devices** | | Cardiac pacemakers – natural and artificial pacemakers-pacemaker batteries-defibrillator- A.C./D.C synchronized defibrillator – stimulators – bladder stimulators – heart lung machine  various types of oxygenators- kidney machine – hemodialysing units – peritoneal dialysis |
| **UNIT III:**  **Clinical and Operation Theater Equipment** | | Flame photometer – Spectroflurophotometer – pH meters – Audiometer – Endoscopes – Electromagnetic and laser blood flow meters – ventilators – diathermy units – ultrasonic,  microwave diathermy techniques |
| **UNIT IV:**  **Biotelemetry and Safety Instrumentation** | | Design of a biotelemetry system, radiotelemetry with subcarrier – multiple channel telemetry systems- problems in implant telemetry – uses of biotelemetry – physiological effects of 50Hz  current – microshock and macroshock – electrical accidents in hospitals – devices to protect against electrical hazards. |
| **UNIT V:**  **Advances in Biomedical Instrumentation** | Computers in medicine, Lasers in medicine, Endoscopes, Cryogenic Surgery, Nuclear imaging techniques, Computer tomography, Thermography, Ultrasonic imaging systems, Magnetic resonance imaging, Digital substraction angiography, Biomaterial and sensors, Automated drug  delivery system. | | |
| **UNIT VI:**  **Contemporary Issues** | Expert Lectures, Online Seminars - Webinars  <https://www.youtube.com/watch?v=8SnD9ZpbIvE>, and related webinars | | |
| **TEXT BOOKS** | 1. M.Arumugam, Biomedical Instrumentation, Anuradha Publishing   Co.,Kumbakkonam, Tamilnadu 1992.   1. R.S.Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw   Hill, New Delhi,1990.   1. R. S Khandpur, Handbook of Analytical Instruments, Mc Graw Hill,   Education | | |
| **REFERENCE BOOKS** | 1. Jacobson and Webster, Medicine and Clinical Engineering, Prentice Hall of India, New Delhi, 1979 2. Richad Aston, Principles of Biomedical Instrumentation and measurements, Merrill Publishing Co., London, 1990 | | |
| **WEB SOURCES** | 1. https://nptel.ac.in/courses/108/105/108105101/ 2. https://nptel.ac.in/content/storage2/courses/112104039/pdf\_version/lecture23.pdf 3. https://nptel.ac.in/courses/102/108/102108077/ | | |

COURSE OUTCOMES:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Understand the different potentials and equivalent circuits for medical treatment | K1 |
| **CO2** | Get the prior knowledge of fundamental concepts, functioning and applications of |  |
| **CO3** | physiological devices | K2 |
| **CO4** | Study the importance of clinical and operation theatre equipment | K4 |
| **CO5** | Able to handle the telemetry system and protect from the emergency | K4 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | L | L | M | L | S | M | L | L | L | M |
| **CO2** | L | L | M | L | S | M | L | L | L | M |
| **CO3** | L | L | M | L | S | M | L | L | L | M |
| **CO4** | L | L | M | L | S | M | L | L | L | S |
| **CO5** | L | L | M | L | M | M | L | L | L | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 |
| **CO2** | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 |
| **CO3** | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 |
| **CO4** | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 3 |
| **CO5** | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 3 |

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| **Core Practical 1-RADIATION INSTRUMENTATION LAB** | **I Year- I Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 13P | **RADIATION INSTRUMENTATION LAB** | Core | 0 | 0 | 3 | 3 | 0 | 100 |

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| --- |
| **Pre-Requisites** |
| **Atomic and Nuclear Physics- G Level** |
| **Learning Objectives** |
| * Operate alpha, beta and gamma survey meters and detectors to perform radiation survey and understand its detection mechanism. * Find the unknown gamma emitters and alpha emitting isotopes. * Acquire skill on using semiconducting components and to study their characteristics for their effective usage in dosimeters internal circuits. |

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| **Course Details** |
| **List of Practical**   1. Measure the energy resolution of the Gamma ray spectrometer. 2. Identify unknown gamma source using the Gamma ray spectrometer. 3. Verification of inverse square law and to find the hidden source using survey meters. 4. Estimation of efficiency of the alpha counting system. 5. Measure the range and energy of beta particles by feather analysis using the GM counter. 6. Measure the attenuation coefficients of various materials using the GM counter. 7. Measure HVL of various materials using the GM counter 8. Find the resolving time of a GM counter 9. Study the characteristics of a GM tube. 10. NAND and NOR as Universal Building Block 11. OP-Amp amplifications: Adder, Subtractor, Differentiator, Integrator 12. FET Characteristics 13. A/D and D/A convertor 14. IC Regulated power supply |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| CO1 | Understand the functioning of GM counter, alpha, beta counting systems, and survey meters. | K2 |
| CO2 | Understand the construction and working of Gamma ray spectrometer and its inbuilt software to identify the unknown gamma emitting isotope. | K2 |
| CO3 | Understand the operation and calibration techniques. | K2 |
| CO4 | Provide feedback for better design, development and integration with the existing technologies. | K5 |
| CO5 | Provide firsthand information for repair and modification. | K6 |
| K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6-Create | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | S | L | S | S | M | S | M | S |
| **CO2** | S | L | S | L | S | S | M | S | M | S |
| **CO3** | S | L | S | L | S | S | M | S | M | S |
| **CO4** | S | L | S | L | S | S | M | S | M | S |
| **CO5** | S | L | S | L | S | S | M | S | M | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO4** | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO5** | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |

**SKILL ENHANCEMENT COURSE I**

|  |  |
| --- | --- |
| **Name of the Course** | Introduction to Anatomy and Physiology |
| **Credit criteria** | 1 credit |
| **Objective** | To familiar with structure and functions of organs systems and understand the common pathology features of cancers and interpretation of clinico pathological data |
| **Allotted hours** | 15 hours |
| **Preferred time** | First Semester |
| **Course Content** | To study the different organs system and functions, To know the different types of therapy for the treatment of cancer, To identify the different types of organs in X-ray and CT images. |
| **Attendance** | Minimum of 75 % attendance |
| **Examination** | Each of the students should know the anatomy and physiology of the human body given from the consolidated syllabus. It is recommended to obtain 50 % mark in conducing internal examination. Based on the marks obtained, it would be recommended to score the credits. |
| **Course Coordinator** | Dr. C. S. Sureka |

**SEMESTER II**

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| **Core 5- MEDICAL IMAGING TECHNOLOGY** | **I Year- II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 23A | **MEDICAL IMAGING TECHNOLOGY** | Core | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| **Radiological Physics** |
| **Learning Objectives** |
| * Physical principle and components of Radiography, conventional radiography techniques * Physics of Image detectors * Computed Tomography(CT), MRI and Ultrasound Imaging and advances in Diagnostic radiology |

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| **UNITS** | **Course Details** |
| **UNIT 1:**  **Medical Imaging Fundamentals** | Physical Principle of Diagnostic Radiology- Radiography techniques: objectives of radio- diagnosis, Production of X-rays, Bremsstrahlung- characteristics lines- Interactions of X-rays with human body, differential absorption of X-ray beam, factors affecting image quality- patient dose versus image quality- Prime factors (kVp, mAs and SID/SFD). |
| **UNIT II:**  **Physics of Imaging Detectors** | Physics of Imaging Detectors: Physics of generic photon detectors, Quantum efficiency, Direct and Indirect conversion detectors, Photomultiplier Tube (PMT), Charge coupled device, Flat panel detector, CR-DR imaging plates, image intensifier.  Intensifying screens: Principles and function of intensifying screens conventional screens Vs rare earth screens.  X-ray beam Filters: inherent and added filters, purpose of added filters, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolinium, molybdenum)- Heel effect.  Scatter radiation and grids: Factors influencing scatter radiation, objectives and methods for scatter reduction; beam restrictors (diaphragms, cones/cylinders & collimators), grids.  Image Quality: Limitations of projection imaging technique, Contrast media and projections at different angles -  superimposition of overlying structures, spatial frequency, spatial image formation, formation of radiological (latent) image. |
| **UNIT III:**  **Computed Tomography, MRI and Ultrasound Imaging** | Computed Tomography (CT): Principle, CT imaging system, image reconstruction and processing, acquisition and image quality.  Magnetic Resonance Imaging (MRI): NMR Principle, 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, techniques involved MR image acquisition and reconstruction, safety and applications of MRI in radiotherapy for treatment planning.  Ultrasound imaging(US): Interaction of sound waves with body tissues, production of ultrasound- acoustic coupling – image formation – modes of image display – colour Doppler, modern imaging methods, image artifacts- US imaging in radiotherapy for treatment planning. |
| **UNIT IV:**  **Quality assurance in Diagnostic Radiology** | Purpose of QA, QA protocols and procedures, QA test methods for performance evaluation of x-ray diagnostic equipment, QA of mammography, QA of CT equipment, QA of interventional radiology equipment, Dual energy imaging and absorptiometry (DEXA), Patient dose optimization techniques, Dual and Multi-modality Imaging techniques. |
| **UNIT V:**  **Advances in Diagnostic radiology** | Digital radiography: Screen film and digital mammography, Interventional radiology- Continuous and pulsed fluoroscopy, digital subtraction techniques, orthopan tomography (OPG), Cone Beam CT (CBCT). Digital detectors: Dual Energy CT (DECT), Tomosynthesis; detectors based on direct and indirect conversion methods. |
| **UNIT VI:**  **Contemporary Issues** | https://www.youtube.com/watch?v=tW2SjlMGj0Q https://www.youtube.com/watch?v=5\_k6GVMwQ8w https://www.youtube.com/watch?v=lfkPQKje58s |
| **TEXT BOOKS** | 1. Dance, D.R., Christofides, S., Maidment A.D.R., McLean, I.D., Ng.K.H., Diagnostic radiology physics : a Handbook for teachers and students, International Atomic Energy Agency,Vienna, 2014. 2. Christensen’s introduction to the physics of diagnostic radiology, Curry, T.S., Dowdey, J.E., Murry, R.C., Philadelphia: Lea & Febiger, 4th Edition, (1990). |
| **REFERENCE BOOKS** | 1. The essential physics of medical imaging, Bushberg, S.T., Seibert, J.A, Leidholt, E.M. & Boone, J.M., Baltimore: Williams & Wilkins 1st Edition (1990). 2. Physics for diagnostic radiology, Dendy, P.P.& B. Heaton, Bristol & Philadelphia: Institute of Physics Publishing, 2nd Edition (1994). |
| **WEB SOURCES** | https://nptel.ac.in/courses/108/105/108105091/ |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

|  |  |  |
| --- | --- | --- |
| CO1 | Remember physics principles behind the working of components used in Radiography industry | K1 |
| CO2 | Understand conventional and digital radiography techniques and its basics | K2 |
| CO3 | Understand the physics and working of Imaging detectors | K2 |
| CO4 | Understand the basic principles and working of CT, MRI and Ultrasound Imaging | K2 |
| CO5 | Apply the recent advances in Diagnostic radiology | K3 |
| K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **Core 6- EXTERNAL BEAM RADIATION THERAPY** | **I Year- II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 23B | **EXTERNAL BEAM RADIATION THERAPY** | Core | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| Radiological Physics |
| **Learning Objectives** |
| * To apply the knowledge of treatment parameters like Percentage Death Dose, Tissue Phantom Ratios for computing treatment time calculation required for treatment of radiotherapy patients. To check the dosimetry parameter of treatment machines for using dosimetry tools like RFA, phantoms and etc. * To use parameters like treated volume, irradiated volume, hot spot, maximum target dose in choosing a better treatment plan. To adopt and apply 2 D and 3 D simulation techniques CT, MRI, US and PET fusion techniques. * To recognize the need and ability to select proper electron energy for tumors at different depth. * To compare the merits of electron, neutron and X-ray and Gamma ray beams and heavy charged particles and use them prudently for different types of tumors. * To learn periodic reference dosimetry with calibrated ionization chamber and patient specific dose measurement. |

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| **UNITS** | **Course Details** |
| **UNIT I: Dosimetry Parameters** | Central axis dosimetry parameters: percentage depth doses (PDD), tissue air ratio (TAR), back scatter factor/Peak scatter factor (BSF/PSF) - tissue phantom ratio (TPR) - tissue maximum ratio (TMR)- collimator scatter factor, phantom scatter factor and total scatter factors - relationship between TAR and PDD and its applications - relationship between TMR and PDD and its applications – scatter air ratio(SAR) – scatter maximum ratio(SMR)- off axis ratio field factors- surface dose and buildup region- Description and measurement of isodose curves/ charts-Dosimetry data resources. |
| **UNIT II:**  **Phantoms and Beam Modifiers** | Measuring tools/phantoms: Water phantom and Tissue equivalent/solid water phantoms for dosimetry Radiation filed analyzer (RFA), Array detectors for beam analysis, phantom for beam energy check etc.  Beam modifying and shaping devices – Block Cutting machines- wedge filters – universal, motorized and dynamic wedges - treatment planning with wedges– shielding blocks - field shaping, custom blocking - tissue compensation – design of compensators, 2D compensators, 3D compensators- multi leaf collimators (MLC) and microMLC- special considerations in treatment planning - skin dose, field matching, integral dose, DVHs – differential, integral. |
| **UNIT III:**  **Treatment Planning in Teletherapy** | Target volume definition and dose prescription criteria as per ICRU protocols - 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.  Treatment Techniques: Conventional and conformal radiotherapy, Treatment time and Monitor unit calculations, Arc/ rotation therapy - mantle and inverted Y fields. |
| **UNIT IV:**  **Physics of Electron and Particulate Beam Therapy** | Clinical electron beams - energy specification - electron energy selection for patient treatment -depth dose characteristics - beam flatness and symmetry -penumbra- isodose plots-monitor unit calculations- output factor formalisms- effect of air gap on beam dosimetry – effective SSD. |
| **UNIT V: Particle Beam Physics** | Basic proton interaction – Bragg peak, proton scanning techniques, basic neutron interactions, Particulate beam therapy - Relative merits of electron, X-ray, gamma, proton, carbon ion and neutron beams. |
| **UNIT VI:**  **Contemporary Issues** | Expert Lectures, Online Seminars   1. Physics of radiation oncology - <https://youtu.be/rJdvD4qvORQ> 2. Photon dose distribution - <https://youtu.be/r0z2dZlFaR4> (4 Min 12 sec) 3. PDD - <https://youtu.be/yD94bILngLQ> (15 Min) 4. RFA - <https://youtu.be/02yoEvlMWIs> (3 Min) 5. MLC-<https://youtu.be/fGFb0p7jPnw> (6 Min) 6. Wedge filters - <https://youtu.be/wr5JRP4yXaA> (5 Min 24 sec) 7. Electron beams - <https://youtu.be/YqMa24j1cAs> (17 min 36 sec ) |
| **TEXT BOOKS** | 1. Faiz M. Khan, Physics of Radiation Therapy, 5th Edition, Lippincott Williams and Wilkins, (2014). 2. ATTIX, F.H., Introduction to Radiological Physics and Radiation Dosimetry, Wiley, New York (1986) 3. E. B. Podgorsak, Radiation Oncology Physics: A Handbook for teachers and student, International Atomic Energy Agency, Vienna, (2005). |
| **REFERENCE BOOKS** | 1. S.C.Klevenhagen, Physics of Electron Beam Therapy, Medical Physics Hand Book Series No.6, Adam Hilger Ltd.,Bristor, 1st Edition (1981). 2. Radiation Therapy Planning, G.C.Bentel, Macmillan Publishing Co.,New York, 1st Edition (1992). 3. BENTEL, G.C., Radiation Therapy Planning, McGraw-Hill, New York (1996). |
| **WEB SOURCES** | Treatment planning and Delivery - <https://www.estro.org/Courses?category=3> |

**COURSE OUTCOMES**:

**At the end of the course the student will be able to:**

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| **CO1** | Understand the principles behind dosimetry parameters and use them for treatment time calculation | K2 |
| **CO2** | Learnt advanced concepts in image registration, target delineation, treatment  planning for inverted Y fields, SSD and SAD techniques. | K2 |
| **CO3** | Understand the physics behind the electron energy selection. | K2 |
| **CO4** | Clinically evaluate the merits and demerits of different types of ionization  radiation. | K5 |
| **CO5** | Learnt periodic reference dosimetry with calibrated ionization chamber and patient specific dose measurement. | K2 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | M | L | S | S | M | S | L | M |
| **CO2** | S | L | M | L | S | S | M | S | L | M |
| **CO3** | S | L | M | L | S | S | M | S | L | M |
| **CO4** | S | L | M | L | S | S | M | S | L | M |
| **CO5** | S | L | M | L | S | S | M | S | L | M |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 |
| **CO2** | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 |
| **CO3** | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 |
| **CO4** | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 |
| **CO5** | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 |

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| **Core 7- RADIATION BIOLOGY** | **I Year- II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 23C | **RADIATION BIOLOGY** | **Core** | **4** | **0** | **0** | **4** | **0** | **100** |

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

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| **UNITS** | **Course Details** |
| **UNIT I: Cell Biology** | Introduction to cell biology- Biochemistry- Structure of the cell- Cellular components: Plasma membrane, Cytoplasm, Nucleus - Interaction of cells with their environment- Cell metabolism- Life cycle of the cell: Cell cycle, Cell division, Cell synchronization- Cellular abnormalities and introduction to cancer- Semi conservative DNA synthesis, chromosome segregation – Heredity and its mechanisms. |
| **UNIT II: Interaction of Radiation with Cell** | Concepts of microdosimetry- Interaction of radiation with biological system- various stages- Interaction of radiation with cell at atomic level- Interaction of radiation with cell at molecular level- Interaction of radiolysis product with biomolecules: Interaction with proteins, carbohydrates and lipids, DNA damage, DNA Repair, Chromosomal and Chromatid aberrations and Dose response relationships- Interaction of radiation at cellular level: Effects of radiation on cell cycle, Mechanisms of Cell Death- Non targeted effects of radiation. |
| **UNIT III: Radiobiological Models and Radiation Response**  **Modifiers** | Importance of Radiobiological Models- Models based on empirical model: Nominal Standard Dose (NSD) model, Time Dose Fractionation (TDF) factor model- Models based on cell survival curves and isoeffect: Cell survival curve, Random nature of cell killing and poisson statistics: Target theory, Linear Quadratic model, Local effect model- TCP and NTCP based models.  Radiation response modifiers: Physical factors: Treatment time, Radiation dose response, Fractionation – 4R’s of radiobiology, Dose rate effect, Temperature, Linear energy transfer (LET), Relative Biological Effectiveness- Biological factors: Radio sensitivity of tissues, Age-Chemical factors: Impact of molecular oxygen- Oxygen Enhancement Ratio (OER) , Radio sensitizers, Radio protectors and mitigators. |
| **UNIT IV:**  **Biological Effects of Radiation** | Deterministic effects: Early deterministic effects of radiation, concept of LD50/30 and LD 50/60, Acute radiation syndrome, its stages and general clinical subsyndromes- Late deterministic effects of radiation: radiation effects on importance organs and organ systems, induction of cataract, radiation effects on the developing embryo and shortening of life span.  Stochastic effects (Carcinogenesis): Experience on radiation carcinogenesis, radiation epidemiology, linear non-threshold hypothesis, DDREF, cancer risk estimation, cancer caused by radiation exposure, second cancers in RT patients, cancer risk from diagnostic radiology, attributable lifetime risk.  Stochastic effects (Genetic effects): Genetic effects of radiation, genetic diseases in humans, genetic risk estimation, background data from humans and other animals. |
| **UNIT V:**  **Biological Basis of Radiotherapy** | Radiobiological aspects of modern radiotherapy techniques: Brachytherapy, IMRT, Stereotactic radiotherapy, IORT, Protons, high LET sources and Boron Neutron Capture Therapy (BNCT)- Biological Treatment Planning: Tumor control probability (TCP) and Normal tissue complication probability (NTCP) curves, Nominal Standard Dose (NSD), Biologically Effective Dose (BED) and isoeffect dose calculations, Treatment Gap correction, Effective Uniform Dose (EUD), Limitations of dose-volume-based treatment planning, Uses of biological models in treatment planning, Advantages of biological cost functions over dose-volume cost functions, Precautions for using biological models in plan optimization, quantitative Analysis of Normal Tissue Effects in the Clinic(QUANTEC) and strategies for effective use of biological models in plan Optimization. |
| **UNIT VI:**  **Contemporary Issues** | Expert Lectures, Online Seminars - Webinars   1. Cell biology - <https://youtu.be/sL3-79K3u0> (38 Min) 2. Radiation biology: <https://youtu.be/eVFcP-s1lBE> (42Min) 3. Fundamental radiobiology - <https://youtu.be/lkaNFUwf_bM> (51 Min) |
| **Text Books** | 1. C. S. Sureka and C. Armpilia, Radiation biology for Medical Physicists, CRC Taylor & Francis Group, USA, 2017. 2. E. J. Hall, Radiobiology for Radiologists, J. B. Lippincott Co., 5th Edition, (2000). 3. Radiation Biology: A handbook for teachers and students, Training course series No.42, International Atomic Energy Agency, Vienna, 2010. |
| **Reference Books** | 1. G.G. Steel, Basic Clinical Radiobiology, 2nd Edition, Taylor & Francis Ltd, (1997). 2. S. P. Yarmonenko, Radiobiology of Humans and animals, MIR, Publishers, 1st Edition (1990). 3. J. Dutreix, A. Wambersie, Introduction to Radiobiology, CRC Taylor & Francis, USA, (1990). |
| **Web Sources** | IAEA: https://elearning.iaea.org/m2/enrol/index.php?id=276 |

**COURSE OUTCOMES:**

**At the end of the course, the student will be able to:**

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| **CO1** | Understand the structure and behavior of normal and abnormal cells. | K2 |
| **CO2** | Learnt the effects of radiation to be cautious while working with radiation. | K2 |
| **CO3** | Collected information to overcome Radiophobia and to respect radiation. | K2 |
| **CO4** | Learnt to increase the benefits of radiation towards Radiotherapy by reducing its associated risk. | K3 |
| **CO5** | Realized the scope for further research in health care to serve human society. | K5 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | L | S | S | M | M | S | M | M |
| **CO2** | S | L | L | S | S | M | M | S | M | M |
| **CO3** | S | L | L | S | S | M | M | S | M | M |
| **CO4** | S | L | L | S | S | M | M | S | M | M |
| **CO5** | S | L | L | S | S | M | M | S | M | M |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO2** | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO3** | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO4** | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 |

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| **Core 8- NUCLEAR MEDICINE** | **I Year – II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 23D | **NUCLEAR MEDICINE** | **Core** | 4 | 0 | 0 | 4 | 0 | 100 |

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| **Pre-Requisites** |
| Atomic and Nuclear Physics/ Radiological Physics |
| **Learning Objectives** |
| * To study the production of radionuclides used in nuclear medicine and types of production. To learn different types of imaging procedures namely In-vivo and In-vitro studies. * To understand the importance various imaging instruments and their operating principles and to be familiar with various imaging systems and their limitation. * To recall different imaging techniques like two dimensional and three dimensional techniques. * To be able to understand focal plane tomography emission computed tomography, etc. * To narrate Annihilation Coincidence Detection and PET detector scanner design, data Acquisition for PET. To relate working of Medical cyclotron, radioisotopes produced and their characteristics. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Physics of Nuclear Medicine** | Introduction to Nuclear Medicine, Unsealed Sources, Production of Radionuclide used in Nuclear Medicine; Reactor and accelerator based Radionuclides, Photonuclear activation, Equations for Radionuclide Production, Radionuclide Generators and their operation principles- Preparation and Various usages of Radiopharmaceuticals. In-vivo Non-imaging procedures; Thyroid Uptake Measurements, Renogram, Life Span of RBC, Blood Volume studies etc. |
| **UNIT II:**  **Radionuclide Imaging** | General concept of Radionuclide Imaging and Historical developments. The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Gamma 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. |
| **UNIT III:**  **Imaging Techniques and Image Quality Parameters** | Basic Principles, Two dimensional Imaging Techniques, Three Dimensional Imaging Techniques- Basic Principles and Problem, Focal Plane Tomography. Physics of Imaging system (PET/SPECT): Principles of PET/SPECT, PET Instrumentations, Annihilation Coincidence Detection, PET Detector and Scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET. Fusion imaging PET-CT, PET-MRI. |
| **UNIT IV:**  **Image Reconstruction and Image Quality Parameters** | 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. Spatial Resolution, Factor affecting Spatial Resolution, Methods of Evaluation of Spatial Resolution, Contrast, Noise. National and International protocol followed for Quality Assurance / Quality Control of Imaging equipment (SPECT, PET-CT and SPECT- CT) - IEC/NEMA Protocols. |
| **UNIT V:**  **Radionuclide Therapy** | Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment, Radiation Synovectomy and the isotopes- Delay Tank - waste Disposal Methods used in Nuclear Medicine. |
| **UNIT VI:**  **Contemporary Issues** | Expert lectures, online seminars – webinars   1. Physics of Nuclear medicine - <https://youtu.be/WgCkrfOXLoY> 2. Radionuclide Imaging - <https://youtu.be/wAiCm1du0h4> 3. Filtered Back projection in SPECT - [https://youtu.be/MTBhqcVjQ8Q](https://youtu.be/MTBhqcVjQ8Q%20) 4. Radionuclide Therapy - <https://youtu.be/9mDjSDXSCgI> (58 Min) |
| **TEXT BOOKS** | 1. J.K Fowler, Nuclear Particles in Cancer Treatment, Adam Hilger Ltd., Philadelphia, 1st Edition, 1981. 2. W.H.Blahd, Nuclear Medicine, McGraw Hill Co., New Delhi, 1st Edition, 1980. 3. JA Parker, Nuclear Medicine Physics-A handbook for teachers and students-IAEA, (2014). |
| **REFERENCE BOOKS** | 1. J.Herbert and D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 and 6, Lea and Febiger Co., Philadelphia, 1st Edition, 1984. 2. S.Webb, The Physics of Medical Imaging, Medical Science Series, Adam Hilgers Publications, Bristol, 1st Edition, 1984. 3. Janet F Eary and Winfried Brenner, Nuclear Medicine Therapy, Informa Healthcare, (2007). |
| **WEB SOURCES** | * + - 1. Imaging in nuclear medicine-https:/[/www.open.edu/openle](http://www.open.edu/openlearn/health-sports-)a[rn/health-sports-](http://www.open.edu/openlearn/health-sports-)psychology/health/imaging-medicine/content-section-6.2       2. Nuclear medicine: https://elearning.iaea.org/m2/course/search.php?search=Nuclear+medicine |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

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| **CO1** | Familiar radioisotopes being used in different In-vitro and in-vivo studies. | K2 |
| **CO2** | Know various types of collimator and their uses for various studies. | K2 |
| **CO3** | Learn parameters affecting spatial resolution and methods of evaluation of spatial  resolution. | K2 |
| **CO4** | Learnt the various Nuclear Medicine modalities for molecular imaging. | K3 |
| **CO5** | Understand the therapeutic applications of unsealed radioisotopes. | K3 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | S | M | S | S | M | S | S | S |
| **CO2** | S | M | S | M | S | S | M | S | S | S |
| **CO3** | S | M | S | M | S | S | M | S | S | S |
| **CO4** | S | M | S | M | S | S | M | S | S | S |
| **CO5** | S | M | S | M | S | S | M | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |

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| **Elective 3- NUMERICAL AND COMPUTATIONAL**  **TECHNIQUES** | **I YEAR - II SEMESTER** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 2EA | **NUMERICAL AND COMPUTATIONAL TECHNIQUES** | Elective | 0 | 3 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| Prior knowledge on mathematics and programing language |
| **Learning Objectives** |
| * To provide the importance of the numerical techniques and solving algebraic, transcendental, and simultaneous equations (both direct and iterative methods). * To study the fitting of straight line, parabola and exponential curve using the principles of least square tool. * To understand MATLAB for data files, Objects and images |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Roots of equation** | Roots of equation: Horner's method, Bisection method – False position method – Newton Raphson method – Simultaneous equation: Gauss elimination method – Inversion of a matrix using Gauss elimination method -Method of triangularization Iterative methods : Gauss Jacobi iteration method – Gauss Seidal iteration method - Relaxation Methods. |
| **UNIT II:**  **Curve fitting and Interpolation** | The principles of least squares – Fitting a straight line, Fitting a parabola, Fitting an exponential curve, Sum of the squares of the residuals, Gregory Newton’s forward and backward difference formula for equal intervals – Divided difference – Properties of divided difference – Newton’s divided difference formula – Lagranges interpolation formula for unequal intervals |
| **UNIT III:**  **Numerical Integration and Eigenvalues** | Newton cotes quadrature formula - Trapezoidal rule and error analysis, Simpson’s 1/3rd rule and error analysis - Simpson’s Three-Eight rule, Boole rule, Weddle rule-Power method to find dominant Eigenvalue - Jacobi method – Matrix eigenvalue problem, Eigenvalues of a symmetrictridiagonal matrix – House holder’s method |
| **UNIT IV:**  **Ordinary and Partial differential equation** | Ordinary differential equation– Taylor series method – Basic, Improved and Modified Euler methods – Runge Kutta IV order method for first order differential equation – RK4 method for simultaneous first order differential equations – RK4 method for second order differential equation – Milne’s Predictor – Corrector method. Partial differential equation – difference – quotients – Graphical representation of partial quotients – Classification of Partial differential equations of the second order – Standard five point formula – Diagonal five-point formula –Solution of Laplace’s equation by Liebmann’s iteration. |
| **UNIT V:**  **Mathematical tools** | The MATLAB environment - Data types, Objects and images, File handling, equation solving. Functions and Programs, Defining Functions Functions as Procedures Repetitive Operations Transformation Rules for Functions, Inverse of matrix, Matrix multiplication, Matrix Determinant |
| **UNIT VI:**  **Professional Components** | Expert lectures, online seminars - webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement |
| **TEXT BOOKS** | 1. J. D. Hoffman, Numerical Methods for Engineers and scientists, Marcel Dekker Inc., New York, 2nd Edition, 2001 2. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, New Delhi, 5th Edition, 2012. 3. W. R. Leo, Techniques for Nuclear and Particle Physics Experiments: A How-to Approach, Springer Science & Business Media; 2nd Edition, 2012 4. V. Rajaraman, 1993, Computer oriented Numerical Methods, 3rd Edition. PHI, New Delhi 5. M. K .Jain, S. R. Iyengar and R. K. Jain, 1995, Numerical Methods for Scientific and Engineering Computation, 3rd Edition, New Age Intl., New Delhi. |
| **REFERENCE BOOKS** | 1. A.C. Bajpai, I. M. Calus and J.A. Fairley, Numerical Methods for Engineers and scientists – A students course book John Wiley & Sons, New York, 1st Edition, 1977. 2. T. Veerarajan and T. Ramachandran, Numerical Methods wit programs in C, Tata Mcgraw Hill, New Delhi, 2nd Edition, 2006 3. S. D. Conte and C. de Boor, 1981, Elementary Numerical analysis-an algorithmic approach, 3rd Edition, McGraw Hill,) 4. B. F. Gerald, and P. O. Wheatley, 1994, Applied Numerical analysis, 5th Edition, Addison-Wesley, MA. 5. B. Carnagan, H. A. Luther and J. O. Wilkes, 1969, Applied Numerical Methods, Wiley, New York. |
| **WEB SOURCES** | 1. <https://nptel.ac.in/content/storage2/courses/104101002/downloads/lecture->   [notes/module1/chapter4.pdf](https://nptel.ac.in/content/storage2/courses/104101002/downloads/lecture-notes/module1/chapter4.pdf)   1. <https://www.scribd.com/doc/202122350/Computer-Oriented-Numerical-Methods-by-V-RajaRaman> 2. <https://www.programmingsimplified.com/c/source-code/c-program-find-roots-of-quadratic->[equation](https://www.programmingsimplified.com/c/source-code/c-program-find-roots-of-quadratic-equation) 3. <https://nptel.ac.in/course/122106033/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Deduce the solution for various algebraic, transcendental and imultaneous equations using both direct and iterative methods and Understand the basic concept involved in root finding procedures. | K1, K2 |
| **CO2** | Know the curve fitting and interpolation for equal and difference data and how it is used for practical applications | **K2, K3** |
| **CO3** | Identify the techniques for integration and their applications | **K3,K4** |
| **CO4** | Understand the initial and boundary value problems for ordinary and partial differential equations | **K3, K4** |
| **CO5** | Enhance the problem solving ability using MATLAB and solve the above  numerical problem in MATLAB | **K2** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO2** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO2** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 |

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| **Elective 3- ADVANCES IN MEDICAL PHYSICS** | **I Year- II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 2EB | **ADVANCES IN MEDICAL PHYSICS** | Elective | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| Radiation Dosimetry |
| **Learning Objectives** |
| * To learn the advances in conventional dosimetry towards Micro dosimetry and Nano dosimetry. * To learn the difference between conventional dosimetry and Nanodosimetry and to analyse its various applications. * To realize the importance of Monte Carlo techniques in advanced dosimetry. * To understand the importance of Artificial Intelligence in Medical Physics. * To apply their knowledge towards Industry 4.0/5.0. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Microdosimetry** | Microdosimetric quantities- solid state based microdosimetric techniques- gas based microdosimetry- Biological effects of microdosimtry, evaluation of Monte Carlo techniques for microdosimetry, microdosimetry in targeted radionuclide therapy and radiotherapy- Cellular dosimetry of targeted radionuclides, Microdosimetry of radon progeny, Dose–response relationship, Micro and nanodosimetric calculations, Relationship of absorbed dose, specific energy and track structures. |
| **UNIT II:**  **Nanodosimetry and its Applications** | Definition- Nanodosimetric quantities- charge counting Nanodosimetry: electron based nanodosimetry and ion based nanodosimetry- History- evaluation of positive ion detector for nanodosimetry, Biological effects of nanodosimtry, - structure- optimization- current scenario- future developments- Radiation detector- Radiation protection- Radiation biology- Radiation protection- Gamma spectrometry- Gas sensor- Oncology. |
| **UNIT III:**  **Artificial Intelligence in Medical Imaging- Introduction** | Applying Artificial Intelligence (AI) in Medical Imaging: Computer Aided Detection (CAD), Principles of Computer Aided Image Analysis in Medical Imaging, Machine Learning (ML), and Deep Learning (DL), Content- Based Image Retrieval (CBIR), Radiomics and Radiogenomics- AI in various Medical Imaging Modalities: Limitations of Human Observers, Computer Vision (CV) and AI, Detection of micro calcifications and breast masses, Present Status and Future Directions. |
| **UNIT IV:**  **Artificial Intelligence in CT, MRI, Ultrasound and Nuclear Medicine** | AI in Computed Tomography: CT Reconstruction Algorithms: From concept to Clinical Necessity, Importance of AI based Detection in CT, Present and Future Developments- AI in Magnetic Resonance Imaging (MRI): Developments of AI in MRI, Future directions- AI in Medical Ultrasound: DL Architectures, Applications of DL in Medical US Image Analysis, Future Perspectives- AI in Nuclear Medicine Imaging: Define a Radiomic Diagnostic Algorithm, Applications of AI in Nuclear Medicine, Future Scenarios- Salient features of AI in Medical Imaging: Opportunities and Applications, Challenges, Pitfalls Guidelines for Success, Regulatory and Ethical Issues. |
| **UNIT V:**  **Artificial Intelligence in Radiotherapy** | Importance of Artificial Intelligence (AI) in Radiotherapy- AI Tools for Automated Treatment Planning (ATP): Present ATP Techniques, AI Applications, Advancements and Research guidance in ATP, AI Challenges in ATP.  AI in Intensity Modulated Radiotherapy (IMRT), AI for IMRT Dose Estimation, AI for IMRT Planning support, AI for Modelling IMRT Outcome and Plan Deliverability, AI for Auto-segmentation of OAR in IMRT, Future Directions- AI in Brachytherapy. |
| **UNIT VI:**  **Contemporary Issues** | Expert lectures, online seminars – webinars  AI in Medical Imaging -<https://youtu.be/Hlb-kA9JFyk> |
| **TEXT BOOKS** | 1. H Palmans et al., “Future development of biologically relevant dosimetry” Br J Radiol; 88: 20140392, pp. 1-19, 2000. 2. B. Grosswendt, “Recent advances of nanodosimetry” Radiation Protection Dosimetry Vol. 110, Nos 1-4, pp. 789-799, 2004. 3. Lia M, Silvia D, Loredana C., ‘Artificial Intelligence in Medical Imaging: From theory to Clinical Practice’, USA, CRC Taylor & Francis Group (2019). |
| **REFERENCE BOOKS** | 1. Alexander Wu Chao, “Review of accelerator science and technology”, Volume 2: Medical Applications of Accelerators, https://doi.org/10.1142/7676 , 2009. 2. Dudley T. Goodhead “An Assessment of the Role of Microdosimetry in Radiobiology” Radiation Research; Vol. 91, No. 1, pp. 45-76, 1982. |
| **WEB SOURCES** | 1. Radiation dosimetry - <https://youtu.be/oezjs3VmVvE>  2.GEANT 4DNA -<https://youtu.be/eOBWI0EkKOM>  3.Nanodosimetric Distribution - <https://slideplayer.com/slide/3768950/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Learnt the possibility to measure radiation at DNA level and the importance of  replacing of conventional dosimetric quantities with nanodosimetric quantities. | K2 |
| **CO2** | Understand the basics of Micro dosimetry and Nano dosimetry and importance of Nanodosimetry in Oncology. | K2 |
| **CO3** | Realize the importance of Monte Carlo techniques in advanced dosimetry. | K2 |
| **CO4** | Understand the significance of AI in Medical Imaging and Radiotherapy. | K3 |
| **CO5** | Apply their Medical Physics knowledge towards Industry 4.0/5.0. | K3 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | M | L | S | M | M | S | M | M |
| **CO2** | S | L | M | L | S | M | M | S | M | M |
| **CO3** | S | L | M | L | S | M | M | S | M | M |
| **CO4** | S | L | M | L | S | M | M | S | M | M |
| **CO5** | S | L | M | L | S | M | M | S | M | M |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO2** | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO3** | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO4** | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |

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| **Elective 4- SOLID STATE PHYSICS** | **I YEAR - II SEMESTER** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 2EC | **SOLID STATE PHYSICS** | **Elective** | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| Solid State Physics - UG level |
| **Learning Objectives** |
| * Understand the principle in the formation of bonding in materials and the structure related aspects of the crystal. * Study the various theories to explain the specific heat and magnetic properties of solids. * Know the implication of band theory in sculpturing the semiconducting properties of solids and, the mechanism of superconductivity and its applications. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Bonding in Solids** | Ionic Bonding; Bond Energy of NaCl, Lattice Energy of Ionic Crystals, Madelung Constant – Properties of Ionic Solids – Co-valent Bond; Saturation, Directional Nature, Hybridization, Properties – Metallic Bond; Properties – Intermolecular Bonds; Van der Waal’s bonds, Dispersion Bonds, Dipole Bonds, Hydrogen Bonds. |
| **UNIT II:**  **Crystal Physics** | Types of Solids – Lattice, Basis and Crystal Structure – Unit Cells, Lattice Parameters, Primitive Cells – Crystal Systems, Bravais Lattice –Symmetry Elements, Types, Combination– Directions, Planes and Miller Indices – Reciprocal Lattice- X-ray Diffraction, Bragg’s Law, Powder Method (Laue’s Interpretation). |
| **UNIT III:**  **Magnetics and Ceramics** | MAGNETIC MATERIALS: Classification of magnetic materials -dia, para. ferro, anti-ferro and ferri magnetic materials (qualitative) domain theory - soft and hard magnetic materials - ferroelectricity - ferrites and their uses.  CERAMICS: Classification of ceramic materials and its uses - structural features - production techniques - mechanical properties. |
| **UNIT IV:**  **Dielectric Properties** | Band theory of solids –classification of insulators, Semiconductors, conductors – intrinsic and extrinsic semiconductor – Carrier concentration for electron - Barrier Potential Calculation –- Polarization – frequency and temperature effects on polarization-dielectric loss-Clausius Mosotti relation-determination of dielectric constants. |
| **UNIT V:**  **Superconductors** | Mechanism of Super Conductors – Effect of Magnetic Field – Resistivity – Critical Currents – Meissner Effect – Thermal Properties – Penetration Depth – Type I and Type II Superconductors – London’s Equations – BCS Theory –Josephson’s Effect –Applications; Superconducting Magnets, High Tc Superconductors |
| **UNIT VI:**  **Contemporary Issues** | Expert Lectures, Online Seminars - Webinars  <https://www.youtube.com/watch?v=faep3w1l0Ms>Organic electronics |
| **TEXT BOOKS** | 1. S.O. Pillai, Solid State Physics, New Age International Publishers, 6th Edition, 2015. 2. Solid State Physics, R.K. Puri, V.K. Babbar, S.Chand, 1st Edition, 1996. 3. Elementary Solid State Physics: Principles and Applications, M.A.Omar, Pearson Education Pvt. Ltd., Delhi, India, 4th Edition, 2004. |
| **REFERENCE BOOKS** | 1. A.K. Saxena, Solid State Physics, Macmillan Publishers India Ltd., 2nd Edition, 2013. 2. Solid State Physics: Structure and Properties of Materials, A.M.Wahab, Narosa Publishing house, New Delhi, India, 2nd Edition, 2007. |
| **WEB SOURCES** | <https://nptel.ac.in/courses/115/101/115101012/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Know the various types of bonding in solids | K1 |
| **CO2** | Understand the structural aspects and properties of crystals | K2 |
| **CO3** | Understand the thermal behavior and magnetic characteristics of solids | K2 |
| **CO4** | Analyze the formation of energy bands in solids |  |
| **CO5** | and semiconducting properties of solids | K4 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | L | L | L | L | L | L | L | M |
| **CO2** | S | L | L | L | L | L | L | L | L | M |
| **CO3** | S | L | L | L | L | L | L | L | L | S |
| **CO4** | S | L | L | L | L | L | L | L | L | M |
| **CO5** | S | L | L | L | L | L | L | L | L | M |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO2** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO3** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| **CO4** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO5** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |

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| **Elective 4-** **BIOLOGICAL DOSIMETRY** | **I Year – II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 2ED | **BIOLOGICAL DOSIMETRY** | **Elective** | 3 | 0 | 0 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| Radiation Biology |
| **Learning Objectives** |
| * To know the biomarkers used for biological dosimetry. * To understand the protocol to perform dosimetry using lymphocytes. * To learn the basics of various techniques available to perform biological dosimetry. * To understand the importance cell survival based analysis to measure the biological effects of radiation. * To learn the procedures need to be followed while handling biological samples. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Biomarkers** | Cytogenetic biomarkers- Biomarkers for nucleotide pool damage and DNA damage- Biomarkers for germline inherited mutations and variants- Biomarkers for induced mutations- Biomarkers for transcriptional and translational changes- Others- Safety of laboratory staff. |
| **UNIT II:**  **Lymphocyte based Biodosimetry** | Phases of biological dosimetry: Sample collection phase, Sample processing phase, Data analysis phase- Radiation Induced Chromosomal Alterations: Radiation induced DNA lesions - Chromosome type aberrations- Unstable aberrations- Stable aberrations- Premature chromosome condensation (PCC). |
| **UNIT III:**  **Techniques and Dose Estimation in Biodosimetry** | Micronuclei (MN) assay- Protocols advantage and disadvantages - Dicentric Chromosome Aberration (DCA) assay- Protocols, Advantage and disadvantages - Fluorescence In Situ Hybridization (FISH) technique- Comet assay- Polymerization Chain Reaction (PCR) - Flow cytometry- Western blot- Enzyme-linked immunosorbent assay (ELISA) - DNA Microarray technology. |
| **UNIT IV:**  **Dose Estimation in Biodosimetry** | Dose Estimation: Cell survival curves – Multi-target single hit model, Linear quadratic Model - Production of an in vitro dose response curve - General Considerations, Physical Considerations, Statistical Considerations - Dose calculation in biological dosimetry - Choice of curves - Number of cells to be analysed - Uncertainty on dose estimates- Dose Assessment - Acute whole body exposure, low dose overexposure cases, Partial body exposure, After delayed blood sampling, After protracted and fractionated exposure. |
| **UNIT V:**  **Emergencies and New Developments in Biodosimetry** | Automation of chromosomal assays - Automated Sample Processing, Automated Image Analysis, Laboratory Information Management System (LIMS) –Investigation of radiation accidents - Chernobyl, The Istanbul accident - Mass Casualty Events - Potential Radiation Exposure, Historical Experience, Role of Biological Dosimetry - Existing Mass Casualty Strategies. |
| **UNIT VI:**  **Contemporary Issues** | Expert lectures, online seminars – webinars   1. Biological & physical effects of radiation (Dosimetry) -<https://youtu.be/7I9s4-IhHH4> 2. Radiation induced chromosomal aberration - <https://youtu.be/9arp4AGzCSc> (49 Min) |
| **TEXT BOOKS** | 1. C. S. Sureka and C. Armpilia Text book on “Radiation biology for Medical Physicists”, CRC Taylor & Francis Group, USA, 2017. 2. Cytogenetic Dosimetry: Applications in Preparedness for and Response to Radiation Emergencies, IAEA, 2011. |
| **REFERENCE BOOKS** | 1. Cytogenetic Analysis for Radiation Dose Assessment - A Manual (TRS-405), IAEA, 2001. 2. E.B. Podgorsak, Radiation Oncology Physics: A Handbook for Teachers and Students, IAEA,2005. 3. Alok Dhawan, Diana Anderson, The Comet Assay in Toxicology: 2nd Edition, Royal Society of Chemistry, 2016. |
| **WEB SOURCES** | <https://youtu.be/fduPJ3F03TY> |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

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| CO1 | Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion. | K1, K5 |
| CO2 | Demonstrate knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter. | K2, K3 |
| CO3 | Use the different nuclear models to explain different nuclear phenomena and the concept of resonances through Briet-Weigner single level formula | K3 |
| CO4 | Analyze data from nuclear scattering experiments to identify different properties of the nuclear force. | K3, K4 |
| CO5 | Summarize and identify allowed and forbidden nuclear reactions based on conservation laws of the elementary particles. | K5 |
| K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | M | S | S | M | L | M | L | L |
| **CO2** | S | L | M | S | S | M | L | M | L | L |
| **CO3** | S | L | M | S | S | M | L | M | L | L |
| **CO4** | S | L | M | S | S | M | L | M | L | L |
| **CO5** | S | L | M | S | S | M | L | M | L | L |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 1 |
| **CO2** | 3 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 1 |
| **CO3** | 3 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 1 |
| **CO4** | 3 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 1 |
| **CO5** | 3 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 1 | 1 |

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| **Core Practical 2- MEDICAL PHYSICS LAB I** | **I Year – II Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 23P | **MEDICAL PHYSICS LAB I** | Lab | 0 | 0 | 3 | 3 | 0 | 100 |

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| **Pre-Requisites** |
| External Beam Radiation Therapy |
| **Learning Objectives** |
| * To determine HVL of Radiography unit. * To perform Quality Assurance of a Radiography unit. * To create manual treatment plans using isodose charts. |

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| **Course Details** |
| **List of Practical**   1. Attenuation of Xrays through various materials and evaluation of HVL. 2. Quality assurance in Radiography. 3. Radiation survey in Radiography. 4. Calibration of radio chromic film and find the unknown dose. 5. Calibrate the Optical Stimulated Luminance Dosimeter (OSLD) and find the unknown dose. 6. Manual Treatment Planning of Single fields. 7. Manual Treatment Planning of Parallel Opposed fields. 8. Manual Treatment Planning of Oblique fields. 9. Manual Treatment Planning of Wedge fields. 10. Monitor unit calculations of simple and complex treatment plans. 11. Treatment time calculation of simple and complex treatment plans. 12. Determination of absolute dose to water for high energy photon and electron beam using TRS-398 protocol. 13. Determining dosimetric leaf gap for dynamic multileaf collimator. 14. Manual calculation for an irregular field by Clarkson method. |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

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| **CO1** | Apply their knowledge on measurements of factors covering penetration of X-ray to various materials. | K3 |
| **CO2** | Measure and verify treatment planning parameters. | K4 |
| **CO3** | Perform quality assurance tests of radiation generating equipment like Radiography | K3 |
| **CO4** | Evaluate a treatment plan for single and parallel opposed fields. | K5 |
| **CO5** | Perform in-vivo dosimetry. | K4 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | L | S | M | S | S | S | S |
| **CO2** | S | M | M | L | S | M | S | S | S | S |
| **CO3** | S | M | M | L | S | M | S | S | S | S |
| **CO4** | S | M | M | L | S | M | S | S | S | S |
| **CO5** | S | M | M | L | S | M | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |

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| **SUMMER TRAINING** | **I Year- Summer Vacation** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 26A | **SUMMER TRAINING** | SEC | - | - | - | 2 | 2 | - |

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| **Pre-Requisites** |
| **Radiological Physics, Radiation Detection and Measurement and Radiation Generators** |
| **Learning Objectives** |
| * To observe the clinical work carried out in a Radiation Oncology Department. * To know the duties and responsibilities of a Medical Physicist and RSO. * To observe the image acquisition process in a Diagnostic radiology Department. * To familiarize the procedure followed to deliver treatment in a Radiotherapy department. * To observe the recommendations followed while handling open isotopes and during image acquisition in Nuclear Medicine Department. * To visualize the construction and working of various equipments used for diagnosis and therapy. * To observe the mechanisms adopted to assure public, occupations and patient safety. |
| **Course Details** |
| Students are encouraged to spend **30 days** during their summer vacation to learn the technical know-how of Medical Physics under the guidance and supervision of Medical Physicists in leading research Hospitals/Institutes/Health Care Industries/ Universities engaged with cancer therapy/research. |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| CO1 | Realized the importance of Medical Physics to serve cancer patients. | K2 |
| CO2 | Realized the responsibilies of a Medical Physicist and RSO in a society. | K2 |
| CO3 | Visualized the routine clinical works carry out by the Medical Physicist. | K2 |
| CO4 | Familiarized the recommendations adopted to execute the treatment safely. | K2 |
| CO5 | Developed basic understanding to learn the second year core courses. | K2 |
| K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**SKILL ENHANCEMENT COURSE 2**

**Online course from MOOC/ SWAYAM/ NPTEL/ Coursera/ e-Pataskala etc.,**

1. MATHLAB related course may be preferred.
2. Online course can be completed at any time before completion of the programme.
3. Credits will be included in the Fourth Semester Marks Statement.
4. It is recommended to complete it during the first year of the programme.

**SEMESTER III**

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| **Core 9- APPLIED ANATOMY AND PHYSIOLOGY** | **II Year – III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33A | **APPLIED ANATOMY AND PHYSIOLOGY** | Core | 4 | 0 | 0 | 4 | 4 | 100 |

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

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Structure & function of organs, systems & their common diseases** | Skin, Lymphatic system, Bone, Joints and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and Ear. |
| **UNIT II: Basic, Radiographic anatomy and tumor pathology** | Anatomy of human body, nomenclature & Surface anatomy, Radiographic Anatomy (including cross sectional anatomy – Identify the different organs/structures on plain x-rays, CT scans and other available imaging modalities. Normal anatomy & deviation for abnormalities. Tumor pathology and carcinogenesis, common pathological features of cancers and interpretation of clinico-pathological data. |
| **UNIT III:**  **Clinical aspects of Radiation Oncology** | Benign and malignant disease, Spread of malignant disease, Staging and grading systems, Treatment intent - Curative & Palliative, Different modalities of cancer management (Radiation Therapy, Surgery, Chemotherapy), Hormone Therapy, Immunotherapy, Radionuclide therapy. Patient management on treatment - side effects related to radiation and dose - Acute & Late effects- Monitoring & common management of side effects. |
| **UNIT IV:**  **Site specific signs, symptoms, diagnosis and management** | Head and Neck, Breast, Gynecological, Gastro-Intestinal tract, Genito-Urinary, Lung &Thorax, Lymphomas & Leukemias & Other cancers including AIDS related cancers. |
| **UNIT V:**  **Professional aspects and role of medical physicists** | General patient care - Principles of professional practice – Medical terminology – Research & professional writing – patient privacy – Ethical & cultural issues- Legal aspects – Confidentiality, informed consent, Health and safety- Management of Biosafety. |
| **UNIT VI:**  **Contemporary Issues** | htt[ps://www](http://www.youtube.com/watch?v=IlcWcuB8VOo).[youtube.com/watch?v=IlcWcuB8VOo](http://www.youtube.com/watch?v=IlcWcuB8VOo)  htt[ps://www](http://www.youtube.com/watch?v=fC4dsZBKvp0).[youtube.com/watch?v=fC4dsZBKvp0](http://www.youtube.com/watch?v=fC4dsZBKvp0) |
| **TEXT BOOKS** | 1. Anatomy and Physiology, Rod R. Seely, Mcgraw-Hill College , 5th Edition, 1999. 2. Pat Archer MS ATC LMP, Lisa A. Nelson BA AT/R LMP, Applied Anatomy and Physiology for Manual Therapists, Published by Lippincott Williams & Wilkins, USA, 2012. |
| **REFERENCE BOOKS** | 1. Normal Radiation Anatomy, Meschan, WB Sunders Company, 8th Edition, 1969. 2. Hollinshead’s Text Book of Anatomy, Cornelius Rosse, LWW, 5th Edition, 1997. |
| **WEB SOURCES** | 1. <https://www.youtube.com/watch?v=F3er9MrXa8A> 2. <https://www.youtube.com/watch?v=X_kbJLyLUGU> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Familiar with structure and function of Organs, systems etc.., | K1 |
| **CO2** | Understand the common pathology features of cancers and interpretation of clinico pathological data. | K2 |
| **CO3** | Understand cancer prevention and public education and early detection and screening. | K2 |
| **CO4** | Recollect professional aspects and role of Medical Physicists. | K1 |
| **CO5** | Know the management of side effects related to radiation and dose. | K4 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **Core 10- Radiation Dosimetry and Standardization** | **II Year – III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33B | **Radiation Dosimetry and Standardization** | Core | 6 | 0 | 0 | 5 | 3 | 100 |

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| **Pre-Requisites** |
| Radiological Physics, Radiation Measurement, Radiation Generators, External Beam Radiation therapy |
| **Learning Objectives** |
| * To learn about ionization chamber theory-design of free air ion chamber, design of parallel plate (FAIC), measurements of Air kerma / Exposure – IAEA TRS-277 protocol. * To understand the measurements of DW for external beams- IAEA TRS 398 - Reference dosimetry for X-rays, Co-60 photons, high energy photons, electrons and protons. * To understand the problems with small field and non-standard field dosimetry- choice of appropriate dosimeter- IAEA TRS 483 protocol. * To be able to understand standardization of beta emitters and electron capture with proportional GM and Scintillation counters. * To learn routine sample measurement with liquid counter and scintillation counting methods for alpha, beta and gamma emitters. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **Radiation Standards** | Primary & Secondary Standards, Traceability, Uncertainly in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure. Limitations of FAIC. Bragg-Gray theory, 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 TRS 483: absolute and relative dosimetry in small field- TRS 398: ND, w, Q : ND, W : KQ,Q0 : KQ, Derivation of an expression for KQ,Q0. Calorimetric standards – Inter-comparison of standard. |
| **UNIT II:**  **Dosimetry of X and Gamma Rays** | 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 evolution of Temperature and pressure correction : Thermometers and pressure gauges. Measurement of temperature and pressure. Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. Parallel plate, cylindrical and spherical ion chambers, Ksat, Two voltage method for continuous and pulsed beams Polarity correction. Measurement of Dw for high-energy Electrons 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. |
| **UNIT III:**  **Brachtherapy dosimetry and Standardization** | Manchester, Paris and Stockholm systems (Intracavitary, interstitial, and surface moulds as applicable)- Paterson Parker tables- 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 TG43/43U1 and other dosimetry formalisms. Graphite and water calorimeters for brachytherapy. Interpolation method for calibration of HDR Ir-192 sources. Calibration of protection level instruments and monitors. |
| **UNIT IV:**  **Neutron Standards & Dosimetry** | Neutron classification, neutron sources, Neutron standards – primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method. Neutron spectrometry, threshold detectors, scintillation detectors & multispheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators. |
| **UNIT V:**  **Standardization of Radionuclide** | Methods of Measurement of radioactivity – Defined solid angle and 4Л counting – Beta gamma coincidence counting – Standardization of beat emitters and electron capture nuclides with proportional, GM and scintillation counters – Standardization of gamma emitters with scintillation spectrometers – Ionization chamber methods – Extrapolation chamber – Routine sample measurements – Liquid counter – Windowless counting of liquid samples – scintillation counting methods for alpha, beta and gamma emitter – Reentrant ionization chamber methods – Methods using (n, ŕ) and (n, p) reactions – Determination of yields of neutron sources – Space integration methods – Solids state detectors. |
| **UNIT VI:**  **Contemporary Issues** | 1. Jan Seuntjens and Simon Duane, Photon absorbed dose standards, [Metrologia,](https://iopscience.iop.org/journal/0026-1394) Volume 46, [Number 2.](https://iopscience.iop.org/issue/0026-1394/46/2) |
| **TEXT BOOKS** | 1. Michael G.Stabin, Radiation Protection and Dosimetry – An Introduction to Health Physics, Springer, 1st Edition, 2007. 2. F.H. Attix, Introduction to Radiological Physics and Radiation Dosimetry, Viley - VCH, Verlog, 1st Edition, 2004. 3. Shaheen Dewji and Nolan E Hertel, Advanced Radiation Protection Dosimetry, CRC Press, (Taylor & Francis Group), 1st Edition, 2019. |
| **REFERENCE BOOKS** | 1. Greening J R, Green S, Charles M W, Fundamentals of Radiation Dosimetry, 3rd Edition, London: Taylor & Francis, 2010. 2. D Baltas, L Sakelliou, N Zamboglou, The Physics of Modern Brachytherapy for Oncology, CRC Press (Taylor and Francis Group), 1st Edition, 2007. |
| **WEB SOURCES** | 1. <https://iopscience.iop.org/article/10.1088/0031-9155/41/1/002> 2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003886/> |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| **CO1** | Apply IAEA – TRS 398 protocols in clinical procedure | K2 |
| **CO2** | Calibrate small and non-standard field dosimetry and protection level monitors | K2 |
| **CO3** | Calibrate photons from Co 60 beams, photons and electrons from linacs | K3 |
| **CO4** | Do Brachytherapy dosimetry using various protocols | K3 |
| **CO5** | Evaluate neutrons emitted from medical linear accelerator | K5 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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| **Core 11-**  **RECENT ADVANCES IN RADIOTHERAPY** | **II Year- III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33C | **RECENT ADVANCES IN RADIOTHERAPY** | Core | 4 | 0 | 0 | 4 | 4 | 100 |
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| **Pre-Requisites** |
| Physics - Graduate level |
| **Learning Objectives** |
| * To be able to differentiate cone and mMLC based X-knife, Gamma knife. To be familiar with evaluation of SRS/SRT treatment plans, * To know the concepts of kVCBCT and MVCBCT and mechanics of breathing methods to manage respiratory motion in radiation treatment. * To understand the concepts of volumetric arc therapy, machine commissioning and quality, dosimetric aspects and treatment planning. To compare VMAT plans with conventional, IMRT planning, patients specific quality assurance, etc. * To study the types of Total Body Irradiation treatments, equipment, principle and treatment planning, dosimetry, quality assurance and commissioning * To recall neutron capture therapy, heavy ion therapy and dosimetry. * To study the special techniques in Brachytherapy * To learn the Information Technology for Medical Physics. |

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| **UNITS** | **Course Details** |
| **UNIT I:**  **IMRT and IGRT** | Intensity Modulated Radiation Therapy (IMRT) principles - MLC based IMRT - step and shoot and sliding window techniques - Compensator based IMRT – Tomotherapy based IMRT, planning process - inverse treatment planning - immobilization for IMRT - dose verification phantoms, dosimeters, protocols and procedures. Volumetric Modulated Arc Therapy (VMAT). Image Guided Radiotherapy (IGRT): IGRT concept, imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation- special phantom, Respiratory gating techniques- Tomotherapy - principle - commissioning - imaging – planning and dosimetry - delivery - adaptive radiotherapy. Treatment with FFF beams- Commissioning, QA protocol and procedures, machine and patient specific QA. |
| **UNIT II:**  **SRS, SRT, SBRT and Cyber knife based therapy** | 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.  Physical, planning, and clinical aspects stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy. Choice of dosimeters for output measurements- Commissioning, QA protocol and procedures, machine and patient specific QA. |
| **UNIT III:**  **Special techniques in external beam therapy** | Total body irradiation (TBI) - large field dosimetry - total skin electron therapy (TSET) - electron arc treatment and dosimetry - intraoperative electron radiotherapy (IORT) for breast cancer- mobile linac.  Principle, applications of proton therapy in radiation oncology, National/International/ IEC requirements for hadron therapy equipment, treatment planning and delivery, proton therapy treatment planning and delivery, beam modifiers safety interlocks for gamma and neutron radiations, induced activity and its minimization, Prescribing, Recording and Reporting Proton Beam Therapy (ICRU Report 78), Carbon ion therapy – physical and biological considerations. Radio immunotherapy. In-vivo dosimetry for patient protection. |
| **UNIT IV:**  **Special techniques & Quality Assurance in Brachytherapy** | 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.). Brachytherapy for breast cancer with I-125 seeds.  Acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment. ISO requirements and QA of brachytherapy sources- QA & acceptance test proforma of AERB for Brachytherapy units. |
| **UNIT V:**  **Information Technology for Medical Physics** | International standards (IEC, DICOM, IHE), General concepts and architecture of HIS/RIS/PACS, Radiotherapy record and verify systems, DICOM objects for patient dosimetry. |
| **UNIT VI:**  **Contemporary Issues** | * + - 1. htt[ps://www](http://www.youtube.com/watch?v=SIy6gKhT3lk).[youtube.com/watch?v=SIy6gKhT3lk](http://www.youtube.com/watch?v=SIy6gKhT3lk)       2. htt[ps://www](http://www.youtube.com/watch?v=5Ftzy5imXDw).[youtube.com/watch?v=5Ftzy5imXDw](http://www.youtube.com/watch?v=5Ftzy5imXDw)       3. htt[ps://www](http://www.youtube.com/watch?v=DFKAFXDguFo).[youtube.com/watch?v=DFKAFXDguFo](http://www.youtube.com/watch?v=DFKAFXDguFo) |
| **TEXT BOOKS** | 1. Steve Webb, The Physics of Three–Dimensional Radiotherapy, Institute of Physics Publishing, Bristol and Philadelphia, 1st Edition, 2002. 2. Faiz M Khan, The Physics of Radiation Therapy, 3rd Edition, Lippincott Williams & Wilkins, USA, 1st Edition, 2003. 3. S. Webb, Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 1st Edition, 2001. |
| **REFERENCE BOOKS** | 1. Oleg s Pyianykh, Digital Imaging and Communications in Medicine, A practical introduction and survival guide, Springer, 2012.. 2. Tsujii, Carbon-Ion Radiotherapy-Principles, Practices, and Treatment Planning, Springer 2014 3. Advances in Radiation Therapy, Mittal, Bharat B., Purdy, James A., Ang, K.K. (Eds.), Springer 1998. |
| **WEB SOURCES** | 1. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5718253/> 2. <https://www.ajmc.com/newsroom/review-outlines-recent-advances-in-radiotherapy-for-cancer> 3. <https://doi.org/10.1186/s41936-019-0083-5> |

**COURSE OUTCOMES**:

**At the end of the course the student will be able to:**

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| --- | --- | --- |
| **CO1** | Understand the introduction to IMRT and IGRT | K2 |
| **CO2** | Learnt about SRS, SRT and Cyber knife based therapy | K3 |
| **CO3** | Understand 4D computed tomography imaging and know heavy ion therapy namely proton and carbon ion etc | K2 |
| **CO4** | Learnt about advances in Brachytherapy | K3 |
| **CO5** | Learnt about Information Technology (IT) for Medical Physics | K5 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | M | M | L | L | S | S | L | L | L | L |
| **CO2** | M | M | L | L | S | S | L | L | L | L |
| **CO3** | M | M | L | L | S | S | L | L | L | L |
| **CO4** | M | M | L | L | S | S | L | L | L | L |
| **CO5** | M | M | L | L | S | S | L | L | L | L |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 |
| **CO2** | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 |
| **CO3** | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 |
| **CO4** | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 |
| **CO5** | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 |

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| **Core 12- RADIATION HAZARDS EVALUATION AND**  **CONTROL** | **II Year – III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33D | **RADIATION HAZARDS EVALUATION AND CONTROL** | **Core** | 6 | 0 | 0 | 5 | 3 | 100 |

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| **Pre-Requisites** |
| Physics - Graduate level |
| **Learning Objectives** |
| * Radiation Protection standards and principles * Radioactive Waste Disposal * Transport of Radioactive Material * Legislation * Radiation Emergencies and their Medical Management |

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| **UNITS** | **Course Details** |
| **Unit 1: Radiation protection standards** | Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – International Commission on Radiological protection and its recommendations – The system of Radiological protection – Justification of practice, Optimization of protection and individual dose limits– potential exposures, dose and constraints – System of protection for intervention – Categories of exposures – Occupational, Public and Medical Exposures – risk factor- permissible levels for neutron flux –Factors governing internal exposure – Radionuclide concentrations in air and water – ALI, DAC and contamination levels-international/national radiation protection standards-ICRP, BSS and AERB, overview of UNSCEAR recommendations. |
| **Unit 2: Principles of Monitoring and Protection and safety in industry** | RPR 2004- Evaluation of external radiation hazards – Effects of distance, time and shielding – shielding calculations – Personnel and area monitoring – Internal radiation hazards – Radio toxicity of different radionuclide and classification of laboratories – Control of contamination – Bioassay and air monitoring – chemical protection – Radiation accidents – disaster monitoring.  Safety in Industrial, Agricultural and Research uses of IR: Use of IR in irradiator, industrial; radiography, nucleonic gauging, well logging and research viz., medical research, industrial research & agricultural research. |
| **Unit 3: Safety in the Medical Uses of Radiation** | Planning and shielding calculations of medical radiation installation – General considerations – Design of diagnostic installations- design of deep therapy, telegamma, accelerators and Brachytherapy installations, SPECT, PET/CT, Medical Cyclotron in the Nuclear Medicine Department and medical radioisotope laboratories- Evaluation of radiation hazards in medical diagnostic therapeutic installations – Radiation monitoring procedures – Protective measures to reduce radiation exposure to staff and patients – Radiation hazards in brachytherapy department and teletherapy departments and radioisotope laboratories – Particle accelerators protective equipment – Handling of patients – Radiation safety during sources transfer operations special safety features in accelerators, reactors. |
| **Unit 4: Radioactive Waste Disposable and Transport of Radioisotopes** | Radioactive Waste – sources of radioactive waste – Classification of waste – Treatment techniques for solid, liquid and gaseous effluents – Concept of Delay Tank and Various Waste Disposal Methods used in Nuclear Medicine. Permissible limits for disposal of waste – sampling techniques for air, water and solids – Geological, hydrological and meteorological parameters – Ecological considerations. Disposal of radioactive wastes – General methods of disposal.  Transportation of radioactive substances – Historical background – General packing requirements – Transports documents – Labeling and marking of packages – Regulations applicable for different modes of transport – Transports by post –Transport emergencies – Special requirements for transport of large radioactive sources and fissile materials – Exemptions from regulations – shipments approval – Shipment exclusive use – Transports under special arrangement – Consignors and carriers responsibilities. |
| **Unit 5: Legislation and Radiation Emergencies and their Medical Management** | Physical protection of sources – Safety and security of sources during storage, use, transport and disposal – Security provisions: administrative and technical – Security threat and graded approach in security provisions.  National legislation – Regulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable safety codes, standards, Guides and Manuals – Regulatory Control – Licensing, inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers and Radiation workers – National Inventories of radiation sources – Import, Export procedures.  Radiation accidents and emergencies in the use of radiation sources and equipment industry and medicine - Radiographic cameras and teletherapy units – Loading and unloading of sources – Loss of Radiation sources and their tracing – Typical accidents cases, Radiation injuries, their treatment and medical management – Case his histories. |
| **TEXT BOOKS** | 1. ICRP, Recommendations of the International Commission on Radiological Protection. ICRP Publication 103 (Users Edition). Ann. ICRP 37(2-4), 2007. 2. Williams, J.R., Thwaites, D.I. (Eds), Radiotherapy Physics in Practice, 2nd Edition, Oxford Univ. Press, Oxford, 2000. 3. Fletcher G.H: Textbook of radiotherapy, Lea and Febiger, Philadelphia, pp.106-107, 1966. |
| **REFERENCE BOOKS** | 1. Atomic Energy Act No.33, 1962. 2. Radiation Protection Rules, Atomic Energy Regulatory Board (AERB), Mumbai, 2004 |
| **WEB SOURCES** | <https://pubs.rsna.org/doi/10.1148/65.6.892>  <https://www.osha.gov/SLTC/radiationionizing/prevention.html> |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

|  |  |  |
| --- | --- | --- |
| **CO1** | Exposed to radiation hazards in medical diagnostic and therapeutic equipment and installations. | K2 |
| **CO2** | Exposed to Radioactive wastes and its sources, types and disposal | K3 |
| **CO3** | Learned the Transportation of radioactive substances and its safe handling | K3 |
| **CO4** | Exposed to National legislation and Regulatory framework | K2 |
| **CO5** | Learning Normal and potential exposure, potential accident situations involving  radioisotopes | K2 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES:**

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | L | L | L | L | L | L | L | L |
| **CO2** | S | M | L | L | L | L | L | L | L | L |
| **CO3** | S | M | L | L | L | L | L | L | L | L |
| **CO4** | M | M | L | L | L | L | L | L | S | S |
| **CO5** | M | M | L | L | L | L | L | L | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO4** | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| **CO5** | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 |

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| **Core 13- ADVANCED RADIATION DOSIMETRY** | **II Year- III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33E | **ADVANCED RADIATION DOSIMETRY** | **Core** | 4 | 0 | 0 | 4 | 4 | 100 |

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| **Pre-Requisites** |
| Radiation Dosimetry and Calibration, External Beam Radiation Therapy and Brachytherapy |
| **Learning Objectives** |
| * Radiation Chemistry and Chemical Dosimetry Internal Radiation Dosimetry * Techniques for Dose calculations * Computers in Treatment Planning and Monte Carlo aided dosimetry |

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| **UNITS** | **Course details** |
| **UNIT I:**  **Radiation Chemistry and Chemical Dosimetry** | Definitions of free radicals and G-value - Kinetics of radiation chemical transformations -Radiation Chemistry of gases and reactions of dosimetry interest - Description of irradiators from dosimetric view point- LET and dose-rate effects - Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects - Radiation polymerisation, effects of radiation on polymers in dosimetry - Formation of free radicals in solids.  Chemical Dosimetry Principles- Definitions of optical density, molar absorption coefficient, Beer- Lambert's law, spectrophotometry –dose estimation techniques- Requirements for an ideal chemical dosimeter Fricke dosimeter - FBX dosimeter - Free radical dosimeter – Ceric sulphate dosimeter- Applications of chemical dosimeters in Radiotherapy. |
| **UNIT II:**  **Internal Radiation Dosimetry** | In-vitro Technique: RIA/IRMA techniques and its principles.  Internal Radiation Dosimetry: Different Compartmental Model; Single Compartmental Model, Two Compartmental Model with and 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. |
| **UNIT III:**  **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. |
| **UNIT IV:**  **Monte Carlo aided dosimetry** | Random variables, discrete random variables, continuous random variables, Probability density functions, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, 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.  Overview of computational codes used in medical physics such as MCNP, Fluka, Geant 4, BEAMnrc etc. |
| **UNIT V:**  **Computers in Treatment Planning** | Scope of computers in radiation treatment planning - Review of algorithms used for treatment planning computations - Pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam, hadron beam (proton/heavy ion) beam and brachytherapy - Factors to be incorporated in computational algorithms. Plan optimization - direct aperture optimization - beamlet optimization - simulated annealing - dose volume histograms - Indices used for plan comparisons - Hardware and software requirements - beam & source library generation. Networking, DICOM and PACS.  Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols. |
| **UNIT VI:**  **Contemporary Issues** | htt[ps://www](http://www.youtube.com/watch?v=08eAe_C1mZ4).[youtube.com/watch?v=08eAe\_C1mZ4](http://www.youtube.com/watch?v=08eAe_C1mZ4)  htt[ps://www.r](http://www.radiation-dosimetry.org/category/radiation-dosimetry/page/4/)a[diation-dosimetry.org/category/radiation-dosimetry/page/4/](http://www.radiation-dosimetry.org/category/radiation-dosimetry/page/4/)  https:/[/www](http://www.youtube.com/watch?v=BjF3Z2gJQbY).[youtube.com/watch?v=BjF3Z2gJQbY](http://www.youtube.com/watch?v=BjF3Z2gJQbY) <https://www.youtube.com/watch?v=gZQ3AUbjJJc> |
| **TEXT BOOKS** | 1. Faiz M. Khan, The Physics of Radiation Therapy, Lippincott Williams & Willkins, Philadelphia, 3rd Edition, 2003. 2. F.H. Attix, Introduction to Radiological Physics and Radiation Dosimetry, Viley–VCH, Verlog, 1st Edition, 2004. |
| **REFERENCE BOOKS** | 1. Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water, IAEA TRS-398, 2006. 2. Ivan Lux and Laszlo Koblinger, Monte Carlo Particle Transport Methods: Neutron and Photon Calculations, 1st Edition, CRC Taylor & Francis, 1990. |
| **WEB SOURCES** | <https://cds.cern.ch/record/932011?ln=en> |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

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| **CO1** | Narrate introduction to Chemistry of Dosimetry | K1 |
| **CO2** | Principles and techniques in Internal Radiation Dosimetry. | K2 |
| **CO3** | Techniques involved in internal dose calculations. | K3 |
| **CO4** | Understood the basics behind Monte Carlo aided dosimetry. | K2 |
| **CO5** | Learnt the application of Computers in Treatment Planning. | K4 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | M | M | M | M | M | M | M | M | M | M |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **Core Practical 3- MEDICAL PHYSICS LAB II** | **II Year- III Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 33P | **MEDICAL PHYSICS LAB II** | Lab | 0 | 0 | 5 | 3 | 5 | 100 |

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| **Pre-Requisites** |
| **Medical Physics Lab I and Radiation Dosimetry** |
| **Learning Objectives** |
| * The main objectives of this course are to: * To determine the calibration factor for ion chamber that is not calibrated. To determine the beam quality correction factor. To measure absolute dose for photon beam using TRS 398 protocol. To measure absolute dose for electron beam using TRS 398 protocol. * To measure PDD curves for different field sizes and energies. To measure flatness and symmetry for photon and electron beams. To measure R50, R100, R90 and practical range of electron beam. * To plot isodose distributions for carcinoma esophagus and carcinoma uterine cervix using three and four fields. To determine interleaf and intraleaf for multileaf collimator of linear accelerator. To check leaf speed and accuracy of MLC. To check variation in leaf position with gantry movement. * To tests temporal accuracy, timer linearity and end error of brachytherapy machine. To perform source strength of Ir-192 brachytherapy source. To perform patient specific QA for IMRT patients. * To check physical integrity of primary and secondary walls of radiotherapy installation by measuring radiation levels using survey meter. |

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| **Course Details** |
| **List of Experiments:**   1. Measurement and Verification of PDD, TAR and TMR values 2. Wedge and Tray factor determination 3. Contrast and spatial resolution (FBCT and CBCT) 4. Evaluation of Profile parameters using Radiation Field Analyzer 5. Effective SSD for electron beams 6. Cross calibration of ion chambers 7. Calibration curve for electron density, HU calibration curve 8. Absolute Calibration of Photon and Electron beams - using TRS 398 9. HU linearity and uniformity and CT noise 10. Quality Assurance of Multileaf Collimator 11. Quality Assurance of a Brachytherapy unit 12. Pretreatment IMRT Quality Assurance 13. Radiation Protection survey of Teletherapy and Brachytherapy installations 14. Quality Assurance of a Linear Accelerator 15. Manual planning of three and four field techniques 16. Autoradiography test for Brachytherapy source in Remote Afterloader unit. 17. CTDI measurement using head and body phantoms. 18. Measurement of slice thickness, tube leakage, and table top exposure in CT. 19. Radiation survey in a Hot lab and Nuclear Medicine department.   **Demonstrations**   1. Immobilization and CT Simulation 2. Contouring and external beam treatment planning (simple cases) 3. Mould room techniques 4. Contouring and brachytherapy planning. 5. Image guidance radiation therapy (planar and CBCT) 6. Respiratory gating techniques 7. Demonstration of array detector |

**COURSE OUTCOMES:**

At the end of the course, the student will be able to:

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| **CO1** | Measure absolute value of radiation emitted from linear accelerator for prescribed monitor units | K3 |
| **CO2** | Apply their knowledge for cross calibration of ion chamber for use in accurate measurements of radiation dose. | K3 |
| **CO3** | Evaluate a treatment plan for three and four fields. | K5 |
| **CO4** | Apply their in-depth knowledge in performing patient specific IMRT-QA. | K3 |
| **CO5** | Survey radiation protection/radiotherapy installations. | K5 |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | M | S | M | S | S | S | S |
| **CO2** | S | M | M | M | S | M | S | S | S | S |
| **CO3** | S | M | M | M | S | M | S | S | S | S |
| **CO4** | S | M | M | M | S | M | S | S | S | S |
| **CO5** | S | M | M | M | S | M | S | S | S | S |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |

**SEMESTER IV**

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| --- | --- |
| **PROJECT** | **II Year- IV Semester** |

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| **Subject**  **Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
| 47V | **PROJECT** | SEC | - | - | - | 7 | - | 100 |

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| **Pre-Requisites** |
| **External Beam Radiation Therapy/ Diagnostic Radiology/ Nuclear Medicine** |
| **Learning Objectives** |
| * To have working knowledge of the clinical diagnostic imaging and/or radiation oncology. To get hands on training with relevant instrumentation * To be familiar with radiation safety practices and procedures including the determination of radiation shielding requirements. * Practical real time exposure to understand the biological effects of radiation and its application for radiation safety and for radiation treatment. * To comply with all applicable regulations and requirements regarding health and safety of self and of others, and of clinical and research ethics and procedures. * Understanding of frontier research and to distinguish the suitable methodology for systematic analysis. |
| **Course Details** |
| Students are encouraged to spend 30-45 days for carrying out the project work under the guidance and supervision of Medical Physicists/ Scientists in leading research Hospitals/ Institutes/ Health Care Industries/ Universities engaged with cancer therapy/ Research. |

**COURSE OUTCOMES**:

At the end of the course the student will be able to:

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| CO1 | Learnt various diagnostic/therapeutic instrumentation and methodology to carry out Radio therapy. | K3 |
| CO2 | Exposed to various methods and precautions needed for their professional life as Medical Physicist. | K3 |
| CO3 | Applied effective communication both orally and in writing. | K3 |
| CO4 | Understand frontier research and systematic analysis. | K2 |
| CO5 | Completed mini research projects. | K6 |
| K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate | | |

**MAPPING WITH PROGRAM OUTCOMES**:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
| **CO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**SKILL ENHANCEMENT COURSE 3**

|  |  |
| --- | --- |
| **Name of the Course** | Tutorials in Medical Physics |
| **Credit criteria** | 2 credits |
| **Objective** | To strengthen the problem solving ability and knowledge of Medical Physicists thereby helping them to clear MRSO examination conducted by Atomic Energy Regulatory Board (AERB), Mumbai. |
| **Allotted hours** | 30 hours |
| **Preferred time** | Fourth Semester |
| **Course Content** | Syllabus recommended by AERB for MRSO certification (Review) which covers Radiological Physics, Radiological Mathematics and Statistical Analysis, External Beam Radiation Therapy, Radiation Detection and Measurement, Radiation Standards, Radiation Biology, Radiation Dosimetry and Calibration, Radiation Protection, Nuclear Medicine, Radiation Hazards Evaluation and Control, Recent advances in Radiotherapy, Advanced Radiation Dosimetry, Radiation Generators, Medical Imaging Technology |
| **Attendance** | Minimum of 75 % attendance |
| **Examination** | Each of the students should solve problems given from the consolidated syllabus. It is recommended to obtain 50 % mark in conducing internal examination. Based on the marks obtained, it would be recommended to score the credits. |
| **Course Coordinator** | Dr. C. S. Sureka |

**SKILL ENHANCEMENT COURSE 4**

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| --- | --- |
| **Name of the Course** | Medical Radiological Safety Officer (MRSO) Training |
| **Credit criteria** | 2 credits |
| **Objective** | To strengthen the knowledge of budding Medical Physicists and help them to clear MRSO examination conducted by Atomic Energy Regulatory Board (AERB), Mumbai. |
| **Allotted hours** | 30 hours |
| **Preferred time** | Fourth Semester |
| **Course Content** | Syllabus recommended by AERB for MRSO certification (Review). |
| **Attendance** | Minimum of 75 % attendance |
| **Examination** | It is recommended to obtain 50 % mark in internal examination. Based on the marks obtained, it would be recommended to score the credits |
| **Course Coordinator** | Dr. C. S. Sureka |

**THE END**