

## RADIATION SAFETY

Course Title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Radiation Safety	2	1	0	1	Class XII pass with Physics and Mathematics as main subjects	NIL

### Learning Objectives

The Learning Objectives of this course are as follows:

- To focus on the applications of nuclear techniques and radiation protection.
- To not only enhance the skills towards the basic understanding of the radiation but also provide the knowledge about the protective measures against radiation exposure.
- To impart all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera etc.

### Learning Outcomes:

After studying this course, the student will be able to:

- Understand and use the applications of nuclear techniques and radiation protection to guard against nuclear radiation hazards.
- Understand and use the units of radiations and their safety limits, the devices to detect and measure radiation.
- Understand and use radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards,
- Use the devices which apply radiations in medical sciences, such as X - r a y, MRI, PET, CT-scan with the required safety measures.

## SYLLABUS

### THEORY COMPONENT

#### Unit 1:

**6 hours**

Radiation and its interaction with matter: Basic idea of different types of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin.

Nuclear Radiation: Basic idea of Alpha, Beta, Gamma neutron radiation and their sources (sealed and unsealed sources).

Interaction of Charged Particles (including alpha particles): Heavy charged particles (e.g. accelerated ions) - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling.

Interaction of Beta Particles: Collision and Radiation loss (Bremsstrahlung).

Interaction of Photons: Linear and Mass Attenuation Coefficients.

Interaction of Neutrons: Collision, slowing down and Moderation.

**Unit 2:****4 hours**

Radiation detection and monitoring devices: Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Thermo- luminescent Dosimetry.

Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, annual limit of intake (ALI) and derived air concentration (DAC).

**Unit 3:****2 hours**

Radiation Units, dosage and safety management: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, annual limit of intake (ALI) and Derived air concentration (DAC).

Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards.

**Unit 4:****3 hours**

Application of radiation as a technique: Application in medical science (e.g., basic principles of X-rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

**PRACTICAL****30 hours**

Minimum five experiments need to be performed from the following, graphs to be plotted using any graphical plotting software

- 1) Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software, (different projectiles/ions to be used by different students).
- 2) Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
- 3) Comparison of interaction of projectiles with  $Z_P = 1$  to 92 (where  $Z_P$  is atomic number of projectile/ion) in a given medium (Mylar, Carbon, Water) using simulation software (SRIM etc).
- 4) SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be  $Z_P = 6$  to 92 on  $Z_A = 16$  to 92 (where  $Z_P$  and  $Z_A$  are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
- 5) Calculation of absorption/transmission of X-rays,  $\gamma$ -rays through Mylar, Be, C, Al, Fe and  $Z_A = 47$  to 92 (where  $Z_A$  is atomic number of atoms to be investigated as targets) using XCOM, NIST (<https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html>).
- 6) Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Gamma ray energies are available in the website <http://www.nndc.bnl.gov/nudat2/>).
- 7) Study the background radiation levels using Radiation meter.
- 8) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
- 9) Study of counting statistics using background radiation using GM counter.
- 10) Study of radiation in various materials (e.g. KSO<sub>4</sub> etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
- 11) Study of absorption of beta particles in Aluminum using GM counter.
- 12) Measurement of gamma ray attenuation co-efficient of aluminium using GM counter.
- 13) Estimation of half thickness for aluminium using GM Counter.

**Essential Readings:**

- Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
- Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
- Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
- Fundamental Physics of Radiology by W J Meredith and B Massey, John Wright and Sons, UK, 1989.
- An Introduction to Radiation Protection by A Martin and S A Harbisor, John Willey and Sons, Inc. New York, 1981.

**Suggestive Readings:**

- Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
- Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
- Thermoluminescence dosimetry by A F Mcknlly, Bristol, Adam Hilger (Medical Physics Hand book 5
- Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
- Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
- IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interim) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), RS-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

**References (for Laboratory Work):**

- Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
- Schaum's Outline of College Physics, by E. Hecht, 11<sup>th</sup> edition, McGraw Hill, 2009.
- Modern Physics by K Sivaprasath and R Murugesan, S Chand Publication, 2010.
- AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
- AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

**Examination scheme and mode:**

Evaluation scheme and mode will be as per the guidelines notified by the University of Delhi.