Homi Bhabha National Institute
(A Deemed to be University u/s 3 of UGC Act, MHRD & an Aided Institution of DAE)
Anushaktinagar, Mumbai – 400094

HBNI On-line Interactive Course on

"Computational Radiation Transport Techniques"

Monday June 02 – Friday July 11, 2025

Every day (other than holidays)

Time: 10:30 - 11:30 hrs

Course Coordinator: Dr. T. Palani Selvam

(pselvam@barc.gov.in)

Faculty: Shri Debasmit Sarkar (**debasmit@barc.gov.in**) and Dr. Arghya Chattaraj (**arghyac@barc.gov.in**)

Bhabha Atomic Research Centre, Mumbai

Target Students: Young researchers engaged in PhD, researchers and faculty members (interested/involved in carrying out research work in radiation transport studies/dosimetry/shielding) from different CI/OCI of HBNI and other Universities.

A. Preamble

Homi Bhabha National Institute (HBNI), a deemed to be University and grant in aid institute of the Department of Atomic Energy has ten **C**onstituent **I**nstitutions (CI) and two **O**ff-**C**ampus **C**entres (**OCC**), which are engaged in fundamental and applied research in basic sciences, mathematics, and engineering sciences. The CI/OCC of the HBNI are engaged in cutting edge and frontline areas of research in different fields. Ionizing radiations are used in medical, research and industrial applications. Radiation transport studies, dosimetry and shielding are integral components of these applications and computational tools are often used. This necessitates acquiring knowledge on various computational techniques on transport of neutral and charged particles in matter. In view of this, HBNI is starting an online interactive course on **"Computational Radiation Transport Techniques"** comprising of 30 lectures (60 minutes duration per lecture). This course would cover deterministic and random sampling techniques of radiation transport. The lectures will be delivered in hybrid mode (**offline and google meet**) by experts in the respective subject areas from Bhabha Atomic Research Centre and HBNI. The course is scheduled during **Monday June 02 – Friday July 11, 2025 (10:30 – 11::30 hrs)**.

The course coordinator is Dr. T. Palani Selvam (**pselvam@barc.gov.in**; **022-69298653**), Radiological Physics & Advisory Division, Health, Safety & Environment Group, Bhabha Atomic Research Centre.

B. Target Students

Target students for the proposed course are young researchers engaged in PhD, researchers and faculty members (involved in carrying out research work in radiation transport studies/dosimetry/shielding) from different CI/OCI of HBNI and other Universities.

C. Registration Fee Structure

1. For participants from DAE organisations which are CIs/OCC of HBNI: **No Registration Fee**
2. For participants from DAE organisations that are not CIs/OCC of HBNI: **₹ 500/-** (plus applicable taxes)
3. Participants from non-DAE organisations: **₹ 1000/-** (plus applicable taxes)
4. If the non-DAE candidate wishes to appear for evaluation exam and receive the credit certificate, an additional fee of **₹ 1000**/- (plus applicable taxes) would be charged

D. Course Structure

The course will be completed in 30 lectures (60 minutes per lecture). The course will be of 600 level and will be a **two credits** course for the students for whom the enrolment date for the PhD programme is **August 01, 2024**. However, if enrollment is **prior to August 01, 2024**, the course will have **four credits**.

S. No.	Topic	Number of Lectures
1	Deterministic Radiation Transport Techniques	12
2	Probability Theory	03
3	Random Sampling Techniques	03
4	Monte Carlo Radiation Transport Techniques	12

There will be assignments and examinations for students who want to earn credit for the course. To earn the credit, the participant should attend more than 75% of the lectures, and clear the examinations with more than 50% overall marks.

E. Registration

Those desirous of participating in the course may register on HBNI AnuVidhya website (**www.AnuVidhya.in**). The registration for the course opens on **Wednesday May 07, 2025 and closes on Friday May 23, 2025.** Those who meet attendance requirement of more than 75%, but do not take assignments and exam can be given participation certificate by HBNI.

F. Submission of Nomination

Research scholars from CIs/OCCs of HBNI and non-DAE Institutions who want to earn credits from the course should submit nomination form through the Chairman, Doctoral Committee or PhD Guide. The faculty and researchers may submit the form through their Department Head. The proforma of nomination form is enclosed. ***It is advised that the nomination form is first submitted to the undersigned prior to online registration/payment etc.*** The nomination form may please be submitted to the Course Coordinator by e-mail **on or before Tuesday May 20, 2025**.

G. Syllabus (Number of Lectures: 30; Duration: 60 min; Number of Credits: 2)

Computational Radiation Transport Techniques

A. Deterministic Radiation Transport Techniques

Particle Interactions, Cross Section Definitions, Particle Streaming - Particle Distributions, The Streaming-Collision Operator, Boundary Conditions, derivation of time-dependent/time-independent Boltzmann transport equation for neutral particles, diffusion equation, discrete ordinate technique – discretization of angle, space and energy, one-dimensional discrete ordinate transport equation, spherical harmonics transport technique.

B. Probability Theory

Introduction to probability theory, binomial distribution, Gaussian distribution and poison distribution, Cauchy distribution, variance, expectation value, probability density function, cumulative probability function, error propagation, Central Limit Theorem.

C. Random Sampling Techniques

Random Numbers, properties of random numbers, random number generators, testing of random numbers, discrete and continuous random variables, random sampling techniques – inversion and rejection techniques with worked examples.

D. Monte Carlo Radiation Transport Techniques

Fundamentals of the Monte Carlo methods of neutral and charged particle transport, single and multiple scattering of charged particles, Condense History Monte Carlo methods, Analog Monte Carlo, random walk – constructing a particle history, scoring, estimators – next event estimator, track length estimator, exponential track length estimator, variance reduction techniques – importance sampling, energy cut off, time cut off, geometry splitting with Russian Roulette, direction biasing, exponential transform, implicit capture, forced collisions, phase-space approach.

Suggested References

E. E. Lewis, W. F. Miller, Jr., "Computational Methods of Neutron Transport", A WILEY-INTERSCIENCE PUBLICATION JOHN WILEY & SONS (1984).

Walter R. Nelson, Theodore M. Jenkins, "Computer Techniques in Radiation Transport and Dosimetry", Plenum Press, New York (1980).

Malvin H. Kalos, Paula A. Whitlock, "Monte Carlo Methods"**,** Second Revised and Enlarged Edition WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim (2008).

Alex F Bielajew, "Fundamentals of the Monte Carlo method for neutral and charged particle transport" (2000).

O. I. Leipunskii, B. V. Novozhilov, V. N. Sakharov and J. V. Dunworth, "The Propagation of Gamma Quanta in Matter", Pergamon Press (**1965**).