Course Code Online Interactive Courses (HBNI)

Dear Sir,

Please find the revised code for the courses to be conducted under the HBNI-PhD program. The courses have been approved by the BOS.

Course 1: Code: RE 510 Computational Radiation Transport Techniques

Credit per course	: 02
Lecture hours per credit	: 15
Total Lecture Hours per Course	: 30

Course 2: Code: RE 511 Radiation Metrology and Dosimetry

Credit per course	: 02
Lecture hours per credit	: 15
Total Lecture Hours per Course	: 30

Course 3: Code: RE 512: Environmental Modelling

Credit per course	: 02
Lecture hours per credit	: 15
Total Lecture Hours per Course	: 30

Course 4: Code: RE 513 Radiation Biology

Credit per course	: 02
Lecture hours per credit	: 15
Total Lecture Hours per Course	: 30

With regards

Vandana Pulhani
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Syllabus Online Interactive Courses (HBNI)

Course 1: Code: RE 510 Computational Radiation Transport Techniques

Credit per course : 02
Lecture hours per credit : 15
Total Lecture Hours per Course : 30
Course Co-ordinator: Dr. Palani Selvam, SO/H, RPAD, BARC, Tel.: 28653,
email: pselvam@barc.gov.in

A. Interaction of Radiation with Matter (10)

Particle Interactions, Cross Section Definitions, Particle Streaming - Particle Distributions, The Streaming-Collision Operator, Boundary Conditions, derivation of time-dependent/time-independent Boltzmann transport equations 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 (10)

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.

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.

C. Radiation Transport Theory (10)

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

References

1. E. E. Lewis, W. F. Miller, Jr., "Computational Methods of Neutron Transport", A WILEY-INTERSCIENCE PUBLICATION JOHN WILEY & SONS (1984).
2. Walter R. Nelson, Theodore M. Jenkins, "Computer Techniques in Radiation Transport and Dosimetry", Plenum Press, New York (1980).
3. Malvin H. Kalos, Paula A. Whitlock, "Monte Carlo Methods", Second Revised and Enlarged Edition WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim (2008).
4. Alex F Bielajew, "Fundamentals of the Monte Carlo method for neutral and charged particle transport" (2000).

Course 2: Code: RE 511 Radiation Metrology and Dosimetry

Credit per course : 02
Lecture hours per credit : 15
Total Lecture Hours per Course : 30
Course Co-ordinator: Dr. Sunil Singh, SO/G, RSSD, BARC, Tel.:22755/25075,
email: bhusunil@barc.gov.in

A. Radiation Metrology (10)

Metrology: Evolution and its need, Global metrology structure and role of various organizations / Institutions, Ionizing radiation metrology and its current status in India.

Quantities and Units: Radiometric Quantities (Particle Number, Radiant Energy, Flux and Fluence), Interaction Quantities (Mass attenuation coefficients, Mass energy transfer coefficient, Mass energy absorption coefficients, stopping power and LET) Dosimetric Quantities (Energy Imparted, Absorbed Dose, Kerma, Exposure, Air-Kerma Rate Constant, Charged Particle Equilibrium (CPE), Relationship between Kerma, Absorbed Dose and Exposure under CPE). Protection Quantities (Equivalent Dose, Effective Dose and Committed doses) and Operational Quantities (Ambient, directional, Personal dose equivalent, ALI and DAC).

Standards and Traceability: Primary/Secondary and Working Standards, Uncertainty in measurement. Primary / secondary standards for air-kerma (Calorimeter, Ionization chamber, Free air ionization chamber, etc), Primary / secondary standards for absorbed dose (Calorimeter, Fricke dosimeters, etc), Primary / secondary standards of radioactivity measurements (4pi beta gamma coincidence systems, 4 pi ionization chamber, HPGe, etc.) and Primary / secondary standards for neutron metrology (MnSO4 bath system, STAG facility, Precision Long Counter, standards sources, etc.).

Traceability of Measurement: Type of radiation sources and their standardization, as per relevant international standards. Calibration of dosimeters used in radiotherapy. Calibration of dose calibrators used for nuclear medicine. Calibration of user's radiation monitors (area monitors, personal monitors), standardization of radioactive solutions, etc. Metrology in Radiation Processing Applications covering dosimetry & metrology requirements in Radiation Processing Applications like Blood Irradiation, Food irradiation, Medical Sterilization etc. Measurement uncertainty in calibration.

B. Radiation Dosimetry (10)

Absorbed dose determination - cavity theories (Bragg-Gray and Spencer Attix), detectors used in radiation dosimetry – ionization chamber and solid-state detectors, intrinsic and absorbed dose energy dependence of detectors

Microdosimetry – Concepts of macro and microdosimetry, mean chord length for convex bodies, microdosimetric quantities – lineal energy, specific energy, frequency and dose mean lineal energies, frequency and dose mean specific energies, single and multi-event distributions, representation of microdosimetric distributions, concept of low dose in microdosimetry, cell dose, working principle of Tissue Equivalent Proportional Counter (TEPC), application of microdosimetry in radiation protections and radiation biology.

C. Internal Dosimetry (10)

Incorporation routes of radionuclides, advancements in biokinetic models and estimation of number of transformations and retention fractions / excretion rates. Computational methodology for bone marrow and endosteum dose due to directly and indirectly ionizing radiation. Tomographic/mesh phantoms for dosimetric models and computation of S-values. Methodology for computation of dose coefficients. Computation of intake and internal dose using in-vivo and in-vitro measurement techniques. In silico studies of radionuclides speciation and transport in body-fluids using All Atom Molecular Dynamics. Mechanism of radionuclide decorporation, computation of internal dose and averted dose following decorporation therapy.

References

1. Fundamentals of Ionizing Radiation Dosimetry, Frank H. Attix, Academic Press
2. GSG-7 – IAEA Safety Guide on Occupational Radiation Protection, 2018
3. ICRU Report 69, Direct determination of the body content of radionuclides. J. ICRU, 3, pp.1-128, 2003.
4. ISO 20553: Monitoring of workers exposed to a risk of internal contamination.
5. ISO 28218: Performance Criteria for Radiobioassay.
6. ISO 27048: Dose Assessment for the monitoring of workers for internal radiation exposure.
7. Individual Monitoring for Internal Exposure of Workers, ICRP Publication 78. Ann. ICRP 27 (3-4), 1997.
8. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2-4), 2007.
9. Occupational Intakes of Radionuclides: Part 1. ICRP Publication 130, Ann. ICRP 44(2), 2015.

Course 3: Code: RE 512: Environmental Modelling

Credit per course : 02
Lecture hours per credit : 15
Total Lecture Hours per Course : 30
Course Co-ordinator: Dr. R B Oza, SO/H, RSSD, BARC, Tel.: 22077, email : rboza@barc.gov.in

A. Meteorology (8)

The hydrostatic equation, Dry and moist adiabatic lapse rates, Nature of solar radiation, Thermal boundary layer, Temperature in the lower atmosphere, Winds, Wind profile in the surface layer, Mean wind speed, Turbulence indicators and atmospheric stability, Pasquill stability classes, Meteorological analysis, Meteorological instruments, General circulation of the atmosphere, Introduction to Numerical Weather Prediction Modeling.

B. Atmospheric Dispersion Modelling (8)

Advection-Diffusion Equation (ADE), Analytical solution of ADE, Numerical Solution of ADE, Gaussian puff model, Gaussian plume model, particle trajectory model, Removal processes in atmospheric dispersion models-radioactive decay, dry-deposition, wet-deposition, Radiological dose assessment using atmospheric dispersion models through various internal and external pathways.

C. Aquatic Dispersion Modelling (14)

Types of aquatic environment–surface water such as rivers, estuaries, lakes, coastal sea, deep sea; and ground water. Fate of contaminants in the aquatic environment-Advection, Diffusion, Dispersion, Chemical and biological processes, Removal processes, Comparative importance of processes: Reynold's number, Peclet number, Damkholer number etc., Dilution factors, Differential equations for simulation of surface water hydrodynamics, Differential equations of solute transport in surface water, Analytical solutions for solute transport in surface water, Numerical solutions for solute transport in surface water, Measurement techniques: Current meters; Tide gauges etc., The subsurface environment- Unsaturated zone, Saturated zone, Aquifers: unconfined, leaky and confined, Water table; Confining beds, Types of rocks, Differential equations for groundwater flow field simulation, Differential equations of solute transport in groundwater, modeling in-situ progeny production during transport of long-lived radionuclides involving decay chains and its importance in radiological impact assessment, Concept of distribution coefficient and its importance with reference to solute transport in groundwater, Analytical solutions for solute transport equations in groundwater, Numerical solutions for solute transport equations in groundwater, Geophysical methods for subsurface characterization: Electrical resistivity imaging, Seismic refraction, Field and laboratory based estimation of groundwater flow parameters such as hydraulic conductivity, velocity, recharge, infiltration rate etc.: constant and falling head permeameter, pumping tests, slug tests, tracer tests, double ring infiltrometer. Field and laboratory-based estimation of dispersion parameters.

References:

1. Aquatic Dispersion Modeling: Numerical Groundwater hydrology, A. K. Rastogi.
2. Hydrogeology and Groundwater Modeling, Neven Kresic.
3. Groundwater Hydrology, David Keith Todd.

4. Surface Water Quality Modeling, Steven C Chapra.

5. Atmospheric Dispersion Modeling, An Introduction to Boundary Layer Meteorology Roland B Stull

6. Atmospheric Chemistry and Physics From Air Pollution to Climate Change, J. H. Seinfeld and S. N. Pandis.

7. Environmental Fluid Mechanics: Hydraulics and Fluid Mechanics by P. N. Modi and S. M. Seth

Course 4: Code: RE 513 Radiation Biology

Credit per course : 02
Lecture hours per credit : 15
Total Lecture Hours per Course : 30
Course Co-ordinator: Dr. Nagesh Bhat, SO/G, RPAD, BARC, Tel.: 23968,
email: nageshnb@barc.gov.in

A. Cell Biology (10)

Basic structure, composition and function of a cell and its organelles. Biomolecules, nucleic acids, proteins, carbohydrates lipids, micro molecules. Concept of gene and gene expression, genetic code, central dogma; replication, transcription, translation. DNA as genetic material: basics of inheritance, genetic variations, mutations. Cell cycle: cell division process, types and significance, cell cycle checkpoints. DNA repair pathways. Cell physiology; cellular respiration, intermediary metabolism, enzyme functions, signal transduction, redox system. Cell death mechanisms. Cellular transformation (carcinogenesis) mechanism.

B. Interaction of Radiation with Cells and its Biological Effects (10)

Action of radiation on living cells, Radiolytic products of water and their interaction with biomolecule (direct and indirect interactions); Nucleic acids, proteins, enzymes, fats; Influence of oxygen, temperature. Cellular effects of radiation, mutations, chromosome aberrations. Factors affecting frequency of radiation induced mutations. Stochastic and deterministic effects of radiation. Radiation syndromes. Law of Bergonie and Tribondeau. In-utero exposure, Genetic effects of radiation. Low dose effects, Linear No threshold Model, radiation induced adaptive response and hormesis.

C. Cell survival and target theories (10)

Survival curve parameters, Model for radiation action, Target theory, Multihit, Multitarget, Modification of radiation damage, LET, RBE, dose rate, dose fractionation, Oxygen and other chemical sensitizers, Anoxic, hypoxic, and energy metabolism inhibitors, Hyperthermic sensitization, Radio-protective agents – Cultured cell line and animal experimentation methods for assessing radiation damage, Oxygen enhancement ratio, Dose modifying factors.

References

1. E. J. Hall and A. J. Giaccia, Radiobiology for the Radiologist, 8th ed. Lippincott Williams & Wilkins, 2018.

2. Edward Alpen. Radiation biophysics 2nd edition. Academic Press 1997.

3. International Atomic Energy Agency (2005). Generic Procedures for a Medical Response during a Nuclear or Radiological Emergency," EPR-Medical-2005, 2005.

4. ICRP, 2003. Biological Effects after Prenatal Irradiation (Embryo and Fetus), ICRP Publication 90, 2003.

5. BEIR VII, Health Risks from Exposure to Low Levels of Ionizing Radiation: in National Research Council 2006. Health Risks from Exposure to Low Levels of. Washington, DC: The National Academies Press., 2006. [Online]. Available: https://doi.org/10.17226/11340.

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