MANGALORE UNIVERSITY

MSc Medical Physics

MPH 403: Radiological Mathematics

Teaching hours: Each Unit – 12 h

Objective:

To teach and familiarise the students with various concepts and principles, numerical and statistical methods; and tools required to learn and understand the various process of radiation and radioactivity data analysis including medical applications.

Course Outcomes:

- The student will learn the concept and principle of various statistical methods and technique for data analysis, error calculations in nuclear measurements, calculation in clinical methods and design of clinical experiments.
- They will learn various numerical methods such as Picard‘s method, Taylor‘s method,. Euler‘s method Newton-Raphson Method etc. They will get acquainted with the concept of Monte Carlo as well.
- They will develop mathematical skills in equation solving and interpolation of different kinds of data.
- They will also learn the computational tools and techniques including use of computational software applications such as METLAB, STATISTICA etc. and programming in C++.

Unit I: Probability, Statistics and Errors

Probability – addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data. Basic ideas of statistical distributions frequency distributions, average or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, median, dispersion, standard deviation, root mean square deviation, standard error and variance, coefficient variation, Accuracy, precision, bias, moments, skewness and kurtosis. Application to radiation detection – uncertainty calculations, Random error, Systematic error, probable error, error propagation, time distribution between background and sample, minimum detectable limit. Binomial distribution, Poisson Distribution, Gaussian distribution, exponential

distribution – additive property of normal variants, confidence limits, Bivariate distribution, Correlation and Regression, Chi-square distribution, t-distribution, F-distribution.

Unit II: Counting and Medical Statistics

Statistics of Nuclear counting – Application of Poisson‘s statistics, Statistics of Radioactive Decay: resolving time and loss of counts, sample counting procedures – Goodness of-fit tests

– Lexie‘s divergence co-efficient - Pearson‘s Chi-square test and its extension – Random fluctuations, Evaluation of equipment performance –Signal-to-noise ratio - selection of operating voltage – Preset of rate meters and recorders – Efficiency and sensitivity of radiation detectors – Statistical aspects of gamma ray and beta ray counting – Special considerations in gas counting and counting with proportional counters – statistical accuracy in double isotope technique. Sampling and sampling distributions – confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis. Calculations Involved with Medical Decisions; Sensitivity, Specificity, Accuracy, Predictive Diagnostic Value

Unit III: Numerical Methods

Why numerical methods, accuracy and errors on calculations – round-off error, evaluation of formulae. Iteration for solving x = g(x), Initial Approximation and Convergence Criteria, Newton-Raphson Method. Taylor Series, approximating the derivation, numerical differentiation formulas. Introduction to numerical quadrature, Trapezoidal rule, Simpson‘s rule. Simpson‘s Three-Eighth rule, Boole rule, Weddle rule. Initial value problems.Picard‘s method, Taylor‘s method. Euler‘s method, the modified Euler‘s method. Runge-kutta method.

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

Unit IV: Roots of equation and Interpolation

Bisection – False position method – Newton Raphson method – Gauss elimination mehod - Gauss Jacobi method – Gauss Seidal method – Inversion of a matrix using Gauss elimination method - LU decomposition - 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 V: Computational Tools and Techniques

Computational packages: Overview of programming in C++, MATLAB/Mathematica and STATISTICA in data analysis and graphical methods.

Reference Books:

1. Hoffman, Numerical Methods for Engineers and scientists – 2nd Edition Revised and expanded.
2. A.C. Bajpai, I.M. Calus and J.A. Fairley Numerical methods for engineers and scientists – a student‘s course book, John Wiley & sons
3. Band W. Introduction to Mathematical Physics
4. Croxton – elementary statistics
5. Dahlberg G. Statistical Method of medical & biology students
6. Krasnorm.L. Ordinary differential equation
7. N.P. Bali & Dr. N.Ch. SrimannarayanaIyergar, A text book of Engineering Mathematics, Laxmi publications, 2001.
8. S. Chandra, A text book of Mathematical Physics, Narosa Publishing House.