Computational Methods in Power System Analysis

Contact Hours **Theory 48**	**Credit Hours** **3**

SUGGESTED COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

CLO	Domain
To carry out, plan and propose the power flow in electric networks using different methods and understand the concepts of basic power system stability**.**	Cognitive
To solve, analyze and discuss the problems in power system in normal as well as faulted state**.**	Cognitive
To solve and analyze the problems in power system protection**.**	Cognitive
To demonstrate and construct individually the one line diagrams and Matrices of complex power systems.	Psychomotor

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):
The course is designed so that students will achieve the following PLOs:

Engineering Knowledge:		**7**	Environment and Sustainability:
Problem Analysis:	√	**8**	Ethics:
Design/Development of Solutions:	√	**9**	Individual and Team Work:
Investigation:	√	**10**	Communication:
Modern Tool Usage:	√	**11**	Project Management:
The Engineer and Society:		**12**	Lifelong Learning:

COURSE OUTLINE:

Matrix algebra
Introduction, Basic concepts and definitions, Determinants, Matrix operations, Linear dependence and rank of a matrix and Linear equations

Incidence and network matrices
Introduction, Graphs, Incidence matrices, Primitive network, Formation of network matrices by singular transformations, Formation of network matrices by nonsingular transformations and Example of formation of impedance and network matrices.

Algorithms for formation of network matrices
Introduction, Algorithm for formation of bus impedance matrix, Modification of the bus impedance matrix for changes in the network and Example of formation and modification of bus impedance matrix, Derivation of loop admitance matrix from bus impedance matrix, Example of derivation of loop admittance matrix from bus impedance matrix.

Three-phase networks
Introduction, Three-phase network elements, Three-phase balanced network elements, Transformation matrices, Three-phase unbalanced network elements, Incidence and network matrices for three-phase networks, Algorithm for formation of three-phase bus impedance matrix, Modification of the three-phase bus impedance matrix for changes in the network and Example of formation and modification of three-phase network matrices.

Short circuit studies
Introduction, Short circuit calculations using Z_{BUS}, Short circuit calculations for balanced three-phase network using Z_{BUS}, Example of short circuit calculations using Z_{BUS}, Short circuit calculations using Z_{LOOP} and Example of short circuit calculations using Z_{LOOP}.

Solution of simultaneous algebraic equations
Introduction, Direct methods for solution of linear algebraic equations, Example of solution of linear equations by direct methods, Iterative methods for solution of linear algebraic equations, Example of solution of linear equations by iterative methods, Methods for solution of nonlinear algebraic equations, Example of solution of nonlinear equations and Comaprison of methods

Load Flow Studies
Introduction, Power system equations, Solution techniques, Acceleration of convergence, Examples of load flow calculations, Voltage Controlled buses, Representation of transformers, Tie line control, Comaprison of methods and Description of load flow program

Numerical solution of differential equations
Introduction, Numerical methods for solution of differential equations, Solution of higher-order

Transient stability studies
Introduction, Swing equation, Machine equations, Power system equations, Solution techniques, Example of transient stability calculations, Exciter and governor control systems, Distance relays and description of transient stability program.

RECOMMENDED BOOKS:

1. Computer Methods in Power System Analysis, Stagg and El-Abiad, International student edition.
2. Computational Methods in Power System Analysis by Reijer Idema, Domenico J.P. Lahaye
3. William D. Stevensons Jr, "Elements of Power System Analysis", McGraw Hill, Latest Ed.
4. B. M. Weedy ,B. J. Cory, N. Jenkins, Janaka B. Ekanayake, Goran Strbac “Electric Power Systems”, John Wiley.

Lecture Tentative Plan

Lecture No	Description
Lecture: 01 Lecture: 02	**Matrix algebra** Introduction, Basic concepts and definitions, Determinants, Matrix operations, Linear dependence and rank of a matrix and Linear equations
Lecture: 03 Lecture: 04	**Incidence and network matrices** Introduction, Graphs, Incidence matrices, Primitive network, Formation of network matrices by singular transformations, Formation of network matrices by nonsingular transformations and Example of formation of impedance and network matrices.
Lecture: 05 Lecture: 06 Lecture: 07	**Algorithms for formation of network matrices** Introduction, Algorithm for formation of bus impedance matrix, Modification of the bus impedance matrix for changes in the network and Example of formation and modification of bus impedance matrix, Derivation of loop admitance matrix from bus impedance matrix, Example of derivation of loop admittance matrix from bus impedance matrix.
Lecture: 08 Lecture: 09 Lecture: 10	**Three-phase networks** Introduction, Three-phase network elements, Three-phase balanced network elements, Transformation matrices, Three-phase unbalanced network elements, Incidence and network matrices for three-phase networks, Algorithm for formation of three-phase bus impedance matrix, Modification of the three-phase bus impedance matrix for changes in the network and Example of formation and modification of three-phase network matrices.
Lecture: 11 Lecture: 12	**Short circuit studies** Introduction, Short circuit calculations using Z_{BUS}, Short circuit calculations for balanced three-phase network using Z_{BUS}, Example of short circuit calculations using Z_{BUS}, Short circuit calculations using Z_{LOOP} and Example of short circuit calculations using Z_{LOOP}.
Lecture: 13 Lecture: 14	**Solution of simultaneous algebraic equations** Introduction, Direct methods for solution of linear algebraic equations, Example of solution of linear equations by direct methods, Iterative methods for solution of linear algebraic equations, Example of solution of linear equations by iterative methods, Methods for solution of nonlinear algebraic equations, Example of solution of nonlinear equations and Comaprison of methods
Lecture: 15 Lecture: 16	**Load Flow Studies** Introduction, Power system equations, Solution techniques, Acceleration of convergence, Examples of load flow calculations, Voltage Controlled buses, Representation of transformers, Tie line control, Comaprison of methods and Description of load flow program
Lecture: 17 Lecture: 18	**Numerical solution of differential equations** Introduction, Numerical methods for solution of differential equations, Solution of higher-order **Transient stability studies** Introduction, Swing equation, Machine equations, Power system equations, Solution techniques, Example of transient stability calculations