CH201: CHEMICAL ENGINEERING MATHEMATICS

The syllabus for the course and 1.5 hr lecture duration for the various topics are indicated below. Lecture notes and all relevant postings for the course can be found at: http://chemeng.iisc.ernet.in/selfassembled/ch201.html

Introduction: (*L1*)
Matrix, differential and integral operators, Linear and non-linear operators.
Matrix Algebra, Linear Equations : (*L2-L5*)
Basic properties and operations of matrices. Symmetric and Hermitian matrices, ranks and determinants. Linear spaces, basis, linear dependence and independence, range and null spaces. Solution of systems of linear equations, rank and inverse, existence and uniqueness of solutions.
Inner Products:(*L6-L9*)
Inner product spaces, Orthogonality of vectors, Gram Schmidt orthogonalization. Adjoint operators, Fredholm's alternative theorems.
Eigenvalues and Eigenvectors:(*L10 - L13*)
Eigenvalues and eigenvectors of matrices, Gerschgorin's theorem, similarity transforms and matrix diagonalization, generalized eigenvectors, Solution of IVPs.
Nonlinear Algebraic Equations:(*L14 - L16*)
Solution of systems of nonlinear equations. Picard iteration, convergent sequences, Cauchy sequences, completeness of metric spaces, fixed points and the contraction mapping theorem.
Ordinary Differential Equations, Sturm Liouville Theory:(*L17-L20*)
2 Point Boundary value problems: Sturm Liouville theory and orthogonal functions. Introduction to self-adjoint operators and properties. Solvability conditions and Frehdholms alternative theorems.
Partial Differential Equations:(*L21-24*)
Fourier Series solutions for elliptic and parabolic PDE's in rectangular and cylindrical co-ordinate systems.

Grading:
Assignments -10%, Mid-Term Exams (September 10th 9:00am, October 21st 9:00am - 40%) Final Exam - 50%
Assignments are an essential part of the learning process, especially where computation is required. Some assignments will involve working with a computer using Fortran/C and Mathematica/Matlab. You will be required to submit assignments on time at regular intervals. The assignment should reflect your own personal effort. Students found copying will be severely penalized.

SUGGESTED REFERENCE BOOKS FOR CH201

Listed below is a collection of references that will be useful for the course. References for some special topics which will not be covered in the course have been included for future reference. * indicates books available in the departmental sub-library. A majority of the other books should be available in the main library.

Linear Operator Theory

1. Davis, H. T., and K. Thompson, *Linear Operators in Engineering with Applications in Mathematica*, Academic Press, 2000.

2. Naylor A. W., and G. R. Sell, *Linear Operator Theory in Engineering and Science*, Holt, Rinehart and Winston, 1971. -Accessible exposition of abstract spaces and operator theory.

3. *Ramkrishna D., and N. R. Amundson, *Linear Operator Methods in Chemical Engineering*, Prentice Hall, 1985. - Abstract spaces and operator theory with applications in chemical engineering. Useful reference for the course.

Linear Algebra

1. Noble B., and J. W. Daniel, *Applied Linear Algebra*, Prentice-Hall International Editions, 1988.

2. Gilbert Strang, *Introduction to Linear Algebra*, Wellesley Cambridge Press, 4th Edition, South Asian Edition, 2009 Accessible and clear text with lots of examples on basic ideas in the linear algebra.

3. Seymour Lipschutz and Marc Lipson, Schaum's Outline Series, *Linear Algebra*, 4th Edition, 2009 A good book to have on your shelf. Contains lots of illustrative examples and a good coverage of required topics.

Basic Numerical Methods

1. Carnahan, B., Luther, H.A. and Wilkes, J.O., *Applied Numerical Methods*, Wiley (1969).

2. *Chapra, S.C. and Canale, R.P., *Numerical Methods for Engineers*, McGraw Hill (1985).

3. *Finlayson, B.A., *Nonlinear Analysis in Chemical Engineering*, McGraw Hill (1980).

4. *Gupta, S.K., *Numerical Methods for Engineers*, Wiley (1995).

5. * Press, W.H.; Teukolsky, S.A., Vetterling, W.T. and Flannery, B.P., *Numerical Recipes in Fortran (or C)*, Cambridge University Press (1992).

6. Dahlquist G., and A. Bjorck, *Numerical Methods*, Prentice Hall, 1974.

7. * Ortega J. M., and W. Poole Jr, *An Introduction to Numerical Methods for Differential Equations*, Pitman Publishing Inc., 1981.

Green's Functions

1. *Stakgold I, *Green's Functions and Boundary Value Problems*, Wiley Interscience, 1979. -- Emphasis on Green's function technique to ODE's, good treatment of Fredholm's alternative theorems and applications to 2 point BVPs

Ordinary Differential Equations

1. Boyce W. E., and R. C. DiPrima, *Elementary Differential Equations and Boundary Value Problems* -A good reference for solution to ODE's, including a chapter on phase plane analysis.

2. *Villadsen, J. and Michelsen, M.L., *Solution of Differential Equation Models by Polynomial Approximation*, Prentice Hall (1978).

Partial Differential Equations-Fourier Series Solutions

1. Churchill R. V and J. W. Brown, *Fourier Series and Boundary Value Problems*, Mc Graw-Hill, 1987. -Lucid and readable account on the application of Fourier series method to solving PDE's and function approximation.

2. Carslaw H. S. and J. C. Jaeger, *Conduction of Heat in Solids*, Oxford, Clarendon Press, 2nd Edition, 1959. -A classic reference, containing solutions for a variety of physical situations and solution techniques that arise in heat conduction.

3. Özisik M. Necati *Heat Conduction*, Wiley-Interscience 1980 -Emphasis on solution techniques-separation of variables technique in rectangular cylindrical and spherical co-ordinate systems, includes Laplace and Fourier transforms, Green's functions etc. A useful reference book.

4. Smith, G. D., *Numerical Solution of Partial Differential Equations*, Oxford University Press (1978).

Integral Equations

1. Baker C. T. H and G. F. Miller, *Treatment of Integral Equations by Numerical Methods*, (1982).

2. Linz P., *Analytical and Numerical Methods for Volterra Equations*, SIAM, 1985.

Finite Element Method

1. Reddy J. N. *An Introduction to the Finite Element Method*, Mc Graw-Hill, Inc. 1993. -A useful introductory book on the subject

2. Claes Johnson, *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Cambridge University Press, 1987. -An advanced book on the analysis of the finite element method.

General Applied Mathematics and Handbooks

1. *Arfken G. B and Hans J. Weber, *Mathematical Methods for Physicists* 4th Edition, Academic Press, Inc., 1995. - Excellent exposition on a wide range of topics, including Sturm-Liouville theory, special functions, Greens functions and integral equations.

2. M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, Dover Editions, 1972.

3. S. Wolfram *The Mathematica Book*, Cambridge University Press, 3rd Edition, 1996.