SYLLABUS FOR ELECTIVES – INTEGRATED MSc. MATHS

18MAT647 **Hemodynamics** **3 0 0 3**

Course Objective:

To enable the students to understand three different circulations in the cardiovascular system. To mathematically model the flow in different arteries to gain insights on changes in hemodynamics in various pathological conditions. To identify research level open problems and model the same.

Unit 1

Microscopic and macroscopic scales, Eulerian and Lagrangian motion, acceleration in flow field, laminar and turbulent flow, steady, oscillatory and pulsatile flow, governing equations – conservation of mass, conservation of momentum - physical interpretation, Fourier series and Bessel Equations.

Unit 2

Introduction to physiology of human circulatory system, rheology of blood, composition of blood, viscosity and density of blood, viscoelasticity of blood, Newtoian and non-Newtonian behaviour of blood, Mechanism of arterial wall, permeability and porosity of different wall layers, Dean number, force balance, pressure, viscosity, shear stress, inertia, and vessel elasticity. Pressure gradient – physical interpretation, Reynolds number and Womersley number.

Unit 3

Principles of blood flow in arteries, parallel plate approximation, uniform circular cross section, constant, oscillatory and pulsatile pressure gradient; no slip conditions- single phase model, quantitative and qualitative analysis of results in the normal and pathological state of cardiovascular disease - hemodynamic perspective.

Unit 4

Recent developments in blood flow modeling, strategy and challenges in biomechanics, Identifying gap in the literature of mathematical modeling, cardiovascular physiology and biomechanics. Identifying research level open problems in the field of hemodynamics.

Text Book / Reference Book/Articles

1. C G Caro and T J Pedley, R C Schroter and W A Seed, The mechanics of the circulation, Cambridge University Press, New York, 2012.
2. Wilmer W Nichols, Michael O'Rourke, McDonald’s Blood Flow in Arteries, Theoretical, Experimental and Clinical Principles, Oxford University Press, New York, 2005.
3. Y C Fung, Biomechanics: Circulation, 2nd edition, Springer, New York, 1993.
4. M Zamir, The Physics of Pulsatile Flow, AIP press Springer, 2000.
5. A C Burton, Physiology and Biophysics of the Circulation, Introductory Text, Book Medical Publisher, Chicago, 1966.
6. M Texon, Hemodynamic basis of atherosclerosis, Hemisphere, Washington D C, 1980.
7. David N Ku, Blood flow in arteries, Annual Review of Fluid Mechanics, Vol.29, pp.399-434, 1997.

8. Ai L and KambizVafai, A coupling model for macromolecule transport in a stenosed arterial wall, International Journal of Heat and Mass Transfer, Vol.49, No.9-10, pp.1568-1591, 2006.

18MAT648 Fourier transform and Distribution Theory 3 0 0 3

Unit1: **Test functions and Distributions**: Introduction-Test function spaces -calculus with distributions –localization-supports of distributions-Distributions as derivatives-convolutions.

Unit 2**: Fourier Transforms:** Basic properties-Tempered distributions-paley-wiener theorems-sobolev's lemma

Unit3**: Applications to Differential Equations**-Fundamental solutions-Elliptic equations

Text Books / Reference Books:

1. Walter Rudin, Functional Analysis, McGraw-Hill Inc., New York (1973). (Chapter 6, 7, 8, 9)
2. R.S. Pathak, A course in distribution Theory, Narosa Publishing course 2001
3. Robert S Strichartz, A guide to Distribution Theory and Fourier Transforms, World Scientific

18MAT649 ADVANCED NUMERICAL ANALYSIS 3 0 0 3

Course Objective:*To help the learners understand the Quantitative analysis of solution of trancendental and polynomial equations, system of linear algebraic equations, ordinary and partial differential equations and interpolation of polynomial approximation by means of computational methods.*

UNIT I :

Transcendental and polynomial equations

Transcendental and polynomial equations: Iteration methods based on second degree equation - Rate of convergence - iterative methods – Methods for finding complex roots – iterative methods : Birge-Vieta method, Bairstow's method, Graeffe's root squaring method

UNIT II

System of Linear Algebraic Equations

System of Linear Algebraic Equations - Direct methods - Gauss Jordan Elimination Method – Triangularization method – Cholesky method – partition method. Error Analysis – Iteration methods : Jacobi iteration method – Gauss - Seidal iteration method – SOR method. Jacobi method for symmetric matrices.

UNIT III

Interpolation and Approximation

Interpolation and Approximation - Hermite Interpolations – Piecewise and Spline Interpolation – Appproximation – Least Square Approximation - Numerical Differentiation - Numerical Integration – Methods based on Interpolation.

UNIT IV

Numerical Solutions of ODE

Ordinary Differential Equations : Multi – step method – Predictor – Corrector method – Boundary value problem – Initial value methods – Shooting method – Finite Difference method (with MATLAB programs).

UNIT V

Numerical solutions of PDE

Partial Differential Equations: Initial and Boundary value problems - Parabolic Problems – one dimension problems with constant coefficients – Elliptic Problems with Dirichlet Condition - Finite difference methods (with MATLAB programs)
(Questions not to be asked from MATLAB)

TEXT BOOKS / Reference Books:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering

Computation, III Edn. Wiley Eastern Ltd., 1993.

2. M.K. Jain, Numerical Solution of Differential Equations, II Edn., New Age

International Pvt Ltd., 1983.

3. Kendall E. Atkinson, An Introduction to Numerical Analysis, II Edn., John Wiley & Sons, 1988.

4. Amos Gilat, MATLAB An Introduction with Applications, John wiley& sons, 2004.

5. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, McGraw-Hill International Edn., 1983.

6. Gordon D Smith, Numerical Solution of Partial Differential Equations – Finite Difference Methods, Oxford University Press, 1985.

18MAT650 Nonlinear Dynamics and Chaos 3-0-0-3

Course objective: The main goal of the course is to introduce and describe nonlinear phenomena in physical systems by only using a minimum background in physics and mathematics. The emphasis is on nonlinear phenomena that may be described by few variables that evolve with time. There will be problem sets that will require use of computer. The computer exercises is mainly based on the use of MATLAB, but students will be free to use different software tools as desired.

Introduction to Nonlinear Dynamics and Chaos, Recent applications of Chaos, Computer and Chaos, Dynamical view of the world.

Basics of nonlinear science: Dynamics, Dynamical Systems, Types of Dynamical Systems, Nonlinearity, Dissipative Systems, Deterministic versus Stochastic Systems, Degree of Freedom, State Space, Phase Space, Attractor.

Stability of solutions to Ordinary Differential Equations.Flows on line, Fixed Points and its Stability, Analytical Approach, Graphical approach, Simulation of Equations.

Elementary Bifurcation Theory: Saddle Node, Transcritical, Pitchfork, Imperfect, Hopf bifurcation. Two dimensional Flows, Simple Harmonic Mass-Spring Oscillator.

Limit Cycle, Ruling out closed orbits, Poincare Benedixson theorem. Butterfly Effect, Chaos, Lorenz Equations, Application of Chaos in sending secret messages, Introduction to Fractals, Dimensions of fractals, Cantor Set and Koch curve.

One dimensional map, Logistic Map, Period doubling Route to chaos, Feigenbaum constants.

Text Book / Reference Book:

1. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering by Steven H. Strogatz (CRC Press; 2nd Edition), 2015.
2. Chaos: An Introduction to Dynamical systems by K. T. Alligood, T. D. Sauer, J. A. Yorke (Springer Verlag), 1996.