23MA811 **Numerical Methods for Boundary Layer Problems** **4-0-0 4**

COURSE OUTCOMES

CO1	The learner will be able to analyse the asymptotic approximation of eigenvalue problems and partial differential equations and apply the method of strained coordinates to their research problems.
CO2	The learner will understand boundary layer problems and be ready to work with their research problem based on Hopf bifurcation.
CO3	The learner can analyse the numerical solution of boundary layer problems and research using WKB approximations and Homogenization theory.
CO4	The learner will be able to understand the concepts of periodic and oscillatory behaviours of boundary layer problems
CO5	The learner will be able to understand the concepts of two dimensions of boundary layer problems.

UNIT I **13 hours**

Regular Perturbation Theory

Asymptotic approximations - regular perturbation for roots of polynomial, differential equations, eigenvalue problems and partial differential equations; method of strained coordinates - eigenvalues of nonlinear boundary-value problems; stationary and Hopf bifurcations.

UNIT II **12 hours**

Boundary Layer Theory

Multiple scales analysis- boundary layer theory for algebraic equations, boundary layer problems – boundary layer theory for nonlinear dynamics - WKB approximation – homogenisation theory.

UNIT III **10 hours**

Numerical Methods for Boundary Layer Problems

Numerical Methods for Boundary Layer problems – Simple Fitted Operator Methods in One Dimension – Simple Fitted Mesh Methods in One Dimension

UNIT IV **10 hours**

Convergence of Fitted Mesh Finite Difference Methods for Linear Reaction-Diffusion Problems in One Dimension – Properties of Upwind Finite Difference Operator on Piecewise Uniform fitted Meshes – Convergence of Fitted Mesh Finite Difference Methods for Linear Convection – Diffusion Problems in One Dimension

UNIT V **10 hours**

Boundary Layers Two Dimensional Problems

Linear Convection-Diffusion Problems in Two Dimensions and their Numerical Solutions – Bounds on the Derivatives of Solutions of Linear Convection-Diffusion Problems in Two Dimensions with Boundary Layers

REFERENCE BOOKS

1. J.J.H. Miller, E.O'Riodrdan, G.I. Shishkin, Fitted Numerical Methods for Singular Perturbation Problems.

2. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, Mc Graw-Hill International Edn., 1983.

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

4. M. Stynes H. G Roos and L. Tobiska (2010). Numerical Methods for Singularly Perturbed Differential Equations Convection-Diffusion and Flow Problems. Springer Verlag.

5. E.P. Doolan, J.J.H.Miller, W.H.A. Schilders, Uniform numerical methods for problems with initial and boundary layers, Boole, Dublin, 1980.

6. R.E. O'Malley, Singular perturbation methods for ordinary differential equations, Springer, New York, 1990.

Evaluation Pattern:

The weightage of the marks :

Midterm – 30 marks

Continuous Assessment - 20 marks (Quizzes/assignments)

At the end of the course, end-of-semester exam- 50 marks.

Skill Development:

To help the learners understand the Quantitative and Qualitative analysis of regular and boundary layer problem solutions. To prepare the learners to understand the computational thoughts and apply new schemes for deriving the apriori and posterior error estimates to boundary layer problems.

To prepare the learners to work with new hybrid methods for their research problems and analyse the approximation of the solution, its stability, and convergence of computational methods.