Sl No	Particulars		
1	Name of the Candidate	Dr.K.R. Jayakumar	
2	Address of the parent institution	Professor and head Department of Mathematics K.S. Institute of Technology 14, Raghuvanahalli Kanakapura main road, Bangalore - 560062	
3	PhD Thesis Title	Laminar Boundary Layer Flow Problems Through Finite Difference Methods	
4	Research guide Name	Dr.A.T. ESWARA	
	Department and Designation	Professor and Head, Department of Mathematics	
5	Date of Registration for PhD	26 – 04 – 2006	
	University /Branch	University of Mysore, Mathematics	
6	Date of Award of PhD degree	07 – 04 – 2012	
7	<u>Brief synopsis</u> In the year 1904, Ludwig Prandtl, the German Professor of Mathematics and Mechanics, laid down the foundation for his boundary layer theory by way of presenting an epoch-making paper entitled “Motion of Fluids with Very Small Friction” in the Third International Congress of Mathematicians at Heidelberg, Germany. Prandtl explained how the flow, in the neighbourhood of a solid body, of fluids with low viscosity could be analysed precisely by making a few simplified assumptions. In one stroke he removed most of the mathematical hurdles from the set of Navier-Stokes equations, and yet managed to retain its essence. Prandtl’s boundary layer concept has brought the theoreticians to the amazing world real fluids from their world of ideal fluids and thereby bridged the gap between classical hydrodynamics and the empirical science of *hydraulics*. Indeed, the rapid advances in mechanics of fluids and its allied branches of science and engineering in the twentieth century are largely due to Prandtl’s boundary layer theory. The present thesis deals with numerical studies of some problems in laminar, incompressible boundary layer theory. Indeed, the present investigation aims at exploring the nature of nonlinear partial differential equations, governing the boundary layer flow and convective heat transfer over different geometries, having wide engineering and technological applications. Due to the nonlinearity and split two-point nature of boundary conditions, the coupled boundary layer equations governing the flow situations in the above problems have been solved by numerical methods. Among the popular numerical methods that are available today, the finite difference methods are fast, efficient and well-suited to boundary layer flow and heat transfer problems. In the present work implicit finite difference methods which are known to be unconditionally stable and hence reliable, have been used. Indeed, attempts have been made to use few finite difference schemes along with quasilinearization technique and also a finite difference scheme due to Keller along with Newton’s method, known as Keller Box method. These methods besides having second order convergence, are fast and hence reliable in getting numerically stable results. The present thesis consists of *five chapters* - the *first* of which is general introduction to laminar boundary layer theory including the description of flow and convective heat transfer phenomena while, the remaining four are concerned with specific problems investigated by the author. Each of these chapters begin with a brief literature survey, the mathematical formulation of the problem along with its analysis are presented, followed by the solution procedure. The effect of various parameters such as transverse magnetic field, unsteadiness, surface mass transfer, viscosity variation parameter, localized wall heating (cooling) etc., on the skin friction and heat transfer coefficients as well as on the velocity and temperature fields have been investigated. The numerical results, presented in tabular and graphical forms, are analyzed and discussed in detail. A brief conclusion sums up the each chapter. Various symbols used are defined as and when they appear in each chapter. However, most commonly used symbols have also been listed at the end of the thesis. The *second chapter* deals with the unsteady MHD natural convection flow from a porous vertical flat plate for both, constant wall temperature (CWT) and constant heat flux (CHF) cases. The unsteadiness in the flow is caused due to impulsive change in the constant wall temperature as well as constant heat flux between the plate and ambient fluid. The effect of suction and injection is included in the analysis. The influence of unsteadiness on local skin friction and heat transfer parameter at all the distances along with variations in the velocity and temperature fields at different levels of the plate are analysed. Numerical results show that magnetic field has a significant effect on local skin friction and heat		

transfer parameter in both CWT and CHF cases. In case of CWT, skin friction is enhanced by injection (blowing) while, heat transfer is found to be decreased by it. In the case of suction, the momentum as well as thermal boundary layer thickness decrease along stream wise locations while the effect of blowing (injection) is just opposite. In case of CHF, the unsteadiness and constant heat flux have a pronounced effect on both skin friction parameter and surface temperature. In fact, these parameters are strongly affected by initial transient time – dependent flow. With the increase of stream wise coordinate, the velocity and temperature found to decrease in the case of suction while, they increase in the case of injection. In case of blowing (injection), it is interesting to note that as time increases the velocity and temperature characterization of dividing streamline attain the ambient conditions faster in CWT case and, more faster in CHF case, as compared to steady flow. The variation of viscosity with temperature in fluids is an interesting macroscopical physical phenomenon that can affect boundary layer behaviour, including its separation and control.

The *third chapter* consists of MHD boundary layer flow and heat transfer with temperature dependent viscosity of the flow over two-dimensional and axisymmetric bodies, with the aim of examining the boundary layer separation and its control. The effect of viscosity variation parameter, mass transfer (suction/injection) parameter and viscous dissipation on skin friction and heat transfer coefficients as well as on the velocity and temperature fields are discussed in detail. The results indicate that the magnetic field decreases both skin friction and heat transfer, while the effect of temperature-dependent viscosity on them is just opposite. The velocity and temperature fields are strongly influenced by both, temperature dependent viscosity and magnetic field. Also, suction causes the location of vanishing skin friction to move down stream while the effect of injection is just reverse. The heat transfer is found to depend strongly on viscous dissipation, but the skin friction is little affected by it. The importance of including the temperature dependent viscosity in this problem is confirmed by the obtained numerical results for skin friction factor and heat transfer rate at the wall. The process of localized wall heating/cooling (in which a certain portion (slot) of the wall is being heated/cooled while the remaining portion is unchanged) is of practical interest for various potential applications including thermal protection, energizing the inner protection of the momentum and thermal boundary layer, and also in boundary layer control.

The *fourth chapter* considers the unsteady MHD mixed convection flow over a vertical plate with localized wall heating (cooling). The time - dependent accelerating, decelerating and fluctuating free streams have been analysed. The effect of unsteadiness on the local skin friction and heat transfer coefficients has been investigated. The behavior of momentum and thermal boundary layers due to unsteadiness, in the buoyancy assisting as well as opposing flows have been discussed. It is remarked here that localized heating/cooling introduces a finite discontinuity in the mathematical formulation of the problem and increases its complexity. In order to overcome this difficulty, a non-uniform distribution of wall temperature is considered at finite sections of the plate. Results indicate that localized wall heating (cooling) as well as unsteadiness on the MHD mixed convection flow over a vertical plate have pronounced effect on both local skin friction coefficient and local Nusselt number. The localized wall heating (through the slot) decreases the local skin friction coefficient whereas, it increases the local Nusselt number. On the other hand, wall cooling (through the slot) decreases both local skin friction coefficient as well as local Nusselt number. The velocity and temperature gradients are found to increase in both buoyancy assisting and buoyancy opposing flows.

Boundary layer flows over a moving or stretching surface are of great importance in view of their relevance to a wide variety of technical applications, especially in the manufacture of fibres in glass and polymer industries. In *fifth chapter*, an analysis is performed to study the steady, nonsimilar MHD boundary layer flow over a moving cylindrical rod. The nonlinear coupled partial differential equations governing the flow have been solved numerically using the Keller box method. The results indicate that the magnetic field enhances the skin friction and heat transfer coefficients, while it reduces the thickness of both momentum and thermal boundary layers. Also, with the increase of viscous dissipation parameter, heat transfer coefficient and the thickness of thermal boundary layer decreases while, they increase with the decrease of viscous dissipation.