Preface

The Navier-Stokes equations are good model for the flow of a wide class of fluids. The underlying constitutive model is a linear Newtonian relationship between shear stress and shear rate is governed by fluid’s (constant) viscosity. The exact solutions of few Navier-Stokes equations are known because of the non-linearity which occurs in the inertial part of these equations. However, many flow situations of interest are such that a number of terms in the equations of motion either disappear automatically or can be neglected, and the resulting equations reduce to a form that can be readily solved. There are many fluids with complex microstructure such as biological fluids, as well as polymeric liquids, suspension, liquid crystal which are used in current industrial processes that show nonlinear viscoelastic behavior, that can not be described by the classical linearly Newtonian model. For such fluids non-linearity occurs not only in the inertial part but also in the viscosity part of the governing equations. The number of exact solutions becomes rare as compared to the analytical solutions of Navier-Stokes equations. But the inadequacy of Navier-Stokes theory to describe rheological complex fluids has led to the development of several theories of non-Newtonian fluids. Amongst these, the fluids of second and third-grade have acquired a special status.

Another important aspect in the study of fluid dynamics is the consideration of Magnetohydrodynamics (MHD) situations. Magnetic fluids are used in many engineering applications that involve electrically conducting fluids. They are
employed, for example, to drive flow, induce stirring, levitation or to suppress turbulence.

Keeping the above aspects into account, the research work reported in this thesis has been divided into eight chapters. In Chapter 0 a brief history of fluid dynamics and introduction of the work is presented.

The Chapter 1 consists of basic ideas, equations and Sumudu transform methods which have been used. Homotopy perturbation Sumudu transform method, Sumudu decomposition method and homotopy analysis Sumudu transform method have been developed and applied to obtain the solutions of advection equations and Fokker-Planck equations. These techniques reduce considerably the computation work while maintaining accuracy.

The solution of the problem of two-dimensional and axisymmetric unsteady flows due to normally expanding or contracting parallel plates by homotopy perturbation Sumudu transform method is discussed in Chapter 2. The results which involve reduced computational effort are in agreement with other solution methods.

The Chapter 3 contains a simple recursive algorithm based on the homotopy perturbation Sumudu transform method which produces the series solution of MHD boundary-layer equations for stretching sheet problem.

In Chapter 4 a simple recursive algorithm based on the homotopy perturbation Sumudu transform method is presented. This method produces the series solution of the two-dimensional viscous flow due to shrinking sheet. The difficulty of the condition at infinity is overcome by the use of Padé approximants.
The Chapter 5 presents a simple recursive algorithm based on the homotopy perturbation Sumudu transform method, which produces the series solution of the two-dimensional viscous flow between slowly expanding or contracting walls with weak permeability.

In Chapter 6, the homotopy perturbation Sumudu transform method, the Sumudu decomposition method and the homotopy analysis Sumudu transform method are applied to find the approximate solutions of nonlinear equation governing the thin flow of a third grade fluid down an inclined plane. A graphical comparison of the numerical results obtained from these methods is also presented.

In Chapter 7, the homotopy perturbation Sumudu transform method is used to find velocity, heat transfer and pressure variation profiles of steady three-dimensional Walter’s B fluid in a vertical channel with porous wall.

In Chapter 8, two analytical techniques namely the homotopy perturbation Sumudu transform method and homotopy analysis Sumudu transform method are presented to obtain the approximate solutions of nonlinear equation governing Jeffery-Hamel flow. The results obtained by these two methods in close agreement with one-another and other methods.

In the concluding Chapter 9, a brief summary of the results obtained in Chapters 1 to 8 are given showing the effectiveness of Sumudu transform methods in analyzing the motion of Newtonian and non-Newtonian fluids. Suggestions for future work are also given.