ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor Dr. Rita Choudhury, Professor and Head, Department of Mathematics, Gauhati University for her constant encouragement, support and guidance to develop an understanding of the subject and in completion of this thesis.

I would like to offer my sincere thanks to the authorities Gauhati University, the pioneer of higher education in Assam for providing me all the necessary research facilities.

I wish to offer my sincere appreciation to all members of the staff of the Department of Mathematics, Gauhati University, Guwahati for their helping outlook, which will always remain fresh in my memory.

I offer my thanks to the Principal, Girijananda Chowdhury Institute of Management and Technology, Guwahati for his valuable support during the progress of my research work.

I am grateful to Prof. U. N. Misra, Department of Mathematics, Girijananda Chowdhury Institute of Management and Technology, Guwahati for his inspiration and co-operation throughout my research work.

I would like to offer my gratitude to my father Late Bodhen Mahanta and mother Mrs. Kamala Mahanta, my uncle Mr. Mukul Mahanta and aunt Mrs. Minati Mahanta for their constant encouragement which has been a source of inspiration to me.

I have the pleasure to thank Dr. Subhash Chandra Martha and Dr. Debasish Dey for their valuable support during the progress of my research work.

At last, but not the least, I would like to acknowledge all my family members, friends and well wishers, who were with me all throughout with their support and encouragement.

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ABSTRACT

The classical theory of isotropic viscous incompressible fluids is based on Newtonian hypothesis. This hypothesis has worked very well in explaining many physical phenomena in various branches of fluid dynamics. But in recent years, especially with the emergence of polymers, it has been found that there are fluids which show a distinct deviation from Newtonian hypothesis.

Our study here attempts to comprehend the non-Newtonian behaviour of fluids and their varied responses to different stimulating circumstances. The inadequacy of Newtonian theory to account for normal stress effect, centripetal pump effect, Merrington’s effect, stress relaxation, memory effects etc., invoke diverse scientific thoughts to generalize the linear relationship given by Newton. Freedom is the essence of Mathematics and this freedom from the bondage of linearity between stress and strain rate tensors led to a great deal of creative work in the non-Newtonian fluid flow theory.

In this work, the visco-elastic fluid model characterized by the second-order fluid is adopted to investigate the flow patterns and analyze the flow behaviour under different valid and suitable boundary conditions. The visco-elastic second-order fluids possess a certain degree of elasticity in addition to viscosity. These fluids are of increasing importance in modern technology due to their growing use in many activities such as molten plastic, paints, drilling and polymer solutions.

Some flow problems of visco-elastic fluids have been studied and are presented in this thesis. The problems studied are (i) Unsteady free convective MHD flow of a visco-elastic fluid past an infinite vertical plate with constant suction and heat sink, (ii) Heat and mass transfer in a visco-elastic MHD flow past a vertical plate under oscillatory suction velocity, (iii) Periodic MHD flow of visco-elastic fluid through a channel with heat transfer, (iv) Mixed convective MHD flow of visco-elastic fluid past a vertical infinite plate with mass transfer, (v) MHD mixed convective oscillatory flow of visco-
elastic fluid in a porous channel, (vi) Visco-elastic fluid flow with heat and mass transfer in a vertical channel through porous medium.

The thesis consists of seven chapters. In chapter I, the outline of the development of the theory on non-Newtonian fluid flow and a brief deduction of the constitutive equation of second-order fluid has been given. Also, a brief review of the relevant areas, literature and motivation of the present work are given in last sections.

In chapter II, the unsteady free convective magnetohydrodynamic flow of a visco-elastic and electrically conducting fluid past an infinite vertical porous plate with constant suction and heat absorbing sinks has been investigated. Approximate solutions of the equations governing the flow have been derived for the velocity and temperature fields, mean skin friction and mean rate of heat transfer by using multi-parameter perturbation technique. The profiles of mean velocity, the mean temperature, the temperature and the skin-friction have been presented graphically for different values of the visco-elastic parameter. The mean skin-friction and the mean rate of heat transfer with corresponding amplitudes and phases have been numerically worked out for different values of the parameters involved in the solution to observe the effects of visco-elastic parameter encountered in the problem under investigation.

In chapter III, the unsteady hydromagnetic flow of an electrically conducting visco-elastic fluid past an infinite vertical porous plate in a porous medium of time dependent permeability under oscillatory suction velocity normal to the plate has been investigated. It is considered that the uniform magnetic field acts normal to the flow and the permeability of the porous medium fluctuates with time. The perturbation technique has been used to solve the problem. The profiles of velocity and skin friction have been presented graphically for different values of parameters involved in the solution to observe the effects of the visco-elastic parameter.

In chapter IV, the unsteady MHD periodic flow of visco-elastic fluid through a planar channel has been investigated. The fluid flow and heat transfer is considered with saturated porous medium in the presence of a transverse magnetic field. Solutions for
the velocity, temperature and skin friction have been obtained. The profiles of velocity and skin friction have been presented graphically for different values of parameters involved in the solution to observe the effects of the visco-elastic parameter.

In chapter V, a theoretical analysis of mixed convective unsteady flow of a visco-elastic incompressible fluid past an accelerated infinite vertical porous plate subjected to uniform suction has been investigated under the influence of a uniform transverse magnetic field. Approximate solutions for fluid velocity, temperature, concentration field and skin friction have been obtained. The effects of various parameters involved in the solution have been studied. The profiles of fluid velocity and the skin friction are presented graphically to observe the effects of the visco-elastic parameter.

In chapter VI, the unsteady MHD oscillatory slip flow of a viscous incompressible electrically conducting optically thin fluid with variable temperature and concentration has been investigated. The flow through a planar channel filled with saturated porous medium is considered. The governing equations of the flow field are solved and the expressions for velocity, temperature, concentration, skin friction, rate of heat transfer and rate of mass transfer are obtained. The velocity profile and the skin friction are analyzed graphically to observe the effect of the visco-elastic parameter involved in the solution.

In chapter VII, a theoretical study of two-dimensional free convective flow of a visco-elastic fluid through porous medium bounded by a uniformly moving long vertical wavy wall and a parallel flat wall in presence of heat and mass transfer has been discussed. The solutions consist of two parts: a mean part and a perturbed part. To solve the perturbed part, long wave approximation has been applied and for the mean part, the well known approximation used by Ostrach has been utilized. Solutions for the velocity, temperature, concentration, skin friction, rate of heat transfer and rate of mass transfer have been obtained. The results are discussed for the positive values of Grashof number for heat transfer (i.e. flow on cooled plate). The visco-elastic effects on velocity profile, temperature field, concentration field, skin friction, are analyzed graphically with the combination of other flow parameters involved in the solution.
The thesis is appended with a wide range of bibliography on the work dealt in various chapters.