SYNOPSIS

The present thesis comprising of six chapters deals with problems in heat transfer by laminar flow of viscous incompressible fluids.

A brief review of the previous studies mainly related to the present work is given in Chapter I.

Chapters II, III and IV deal with problems on free convection while in the last two chapters forced convection problems with variable physical properties are discussed.

Chapter II is devoted to a study of transient free convection flow along a semi-infinite vertical plate moving arbitrarily in its own plane. The boundary layer equations for flow and heat transfer are linearized and the first two approximations are considered. The first approximation corresponds to the case of steady free convection flow while the second approximation corresponds to the response of velocity and temperature fields to the motion of the plate. Laplace transform technique is employed and asymptotic solutions valid for large times and for small times are obtained. In the particular case, when the plate is given an impulsive start, the velocity and temperature distributions for large

times are described by the quasi-steady values while for very small times, the unsteady flow and temperature fields are of the 'shear-wave' type unaffected by the basic steady flow.

In Chapter III, the unsteady free and forced convection flow from a semi-infinite horizontal plate is studied when the plate temperature varies periodically in time about a non-zero mean. Separate solutions for low and high frequency ranges are developed. It is found that for low frequencies, the oscillating component of the heat transfer rate from the plate to the fluid predicts a phase lead of 90° over the plate temperature oscillations where as for high frequencies, the oscillating component of the temperature field is of the 'shear-wave' type unaffected by the steady mean flow, predicting a phase lead of 45° in the heat transfer rate at the plate. The phase lead of the fluctuating part of the skin friction in 'shear-wave' flow is found to be 90° over the plate temperature oscillations.

Fully developed free convection flow, arising due to non-linear variation of density with respect to the temperature difference, between two vertical parallel plates maintained at constant temperatures is dealt with in Chapter IV. Results are compared with the classical case of linear variation of density with temperature.

When one wall is at the ambient temperature, the convective velocities are less than the corresponding velocities for linear density-temperature variations while for other combinations of the plate temperatures, the respective velocities and temperatures are either equal to or greater than the corresponding values of linear density variations.

Chapter V is devoted to a study of the effects of temperature-dependent thermal conductivity. The specific problems considered are - (i) the steady laminar flow and heat transfer from a semi-infinite flat plate, and (ii) unsteady flow and heat transfer from plates and surfaces undergoing a step change in temperature. Case (i) is analysed for two thermal boundary conditions; viz. for constant plate temperature and for constant heat flux at the plate and it is found that a linear variation of thermal conductivity with temperature causes a linear variation in the temperature distribution. For an isothermal plate, the rate of heat transfer at the wall increases as the coefficient of thermal conductivity increases. In case (ii) it is assumed that at time $t=0$, the body undergoes a thermal transient which suddenly increases its temperature by a constant. An integral method is employed to solve the resulting equations. It is observed that a linear variation of thermal conductivity with temperature results in a linear variation in the surface heat flux. In the particular case of heat transfer from a semi-infinite flat plate, it is found that the steady state is reached earlier or is delayed according as the thermal conductivity is more or less than its constant value.

In Chapter VI, a study is made of the forced convection flow of liquids past a heated flat plate with temperature-dependent viscosity and thermal conductivity. Using the Kármán-Pohlhausen technique, velocity and temperature profiles as well as skin friction and heat transfer characteristics are obtained for Prandtl number $\sigma > 1$. It is shown that the velocities decrease while the temperature increase as the coefficient of viscosity increases. The velocity and the temperature within the boundary layer decrease with the increase of Prandtl number. For constant viscosity, the temperature increases linearly with linear increase in the coefficient of thermal conductivity.