SYNOPSIS

Unsteady boundary layers are of considerable importance in many problems of engineering interest. However, the theory of unsteady flows is much less advanced. This is due to the inclusion of one more independent variable in the equations of motion. The situation is further complicated by the fact that unsteadiness may enter a problem in a variety of ways. Recently unsteady boundary layers have received wide interest in view of their applications in many fields of recent origin such as in the rotating stall of a turbine, wing flutter of an aircraft etc.

The present thesis comprising of six chapters deals with the study of unsteady boundary layers in viscous, incompressible fluids.

Chapter I is of review nature, a brief survey of the various aspects of unsteady boundary layers related to the present work is given.

Chapter II is devoted to the study of unsteady free convection from a semi-infinite horizontal plate, whose temperature varies harmonically in time about a non-zero mean. The mean flow is due to buoyancy forces caused by the temperature differences between the plate and the free-stream. The analysis is restricted to small amplitudes only. This enables us to affect linearisation of the equations and still retain the first order effects of temperature fluctuations. Asymptotic solutions valid for low and high frequency ranges are developed. It is found that for low frequencies, the oscillating component of the Nusselt number increases as the Prandtl number increases. For very high frequencies, temperature field is of the 'shear wave' type unaffected by the steady mean flow.

In Chapter III, we study the periodic boundary layer flow of certain second-order fluids around a periodically oscillating cylinder. The amplitude of oscillations is assumed to be small. The velocity field is obtained by a process of successive approximations. It is found that a steady secondary motion is induced at a large distance from the cylinder as in ordinary viscous fluids. The results are applied to the case of an oscillating circular cylinder. The stream lines of the secondary flow are drawn for various values of the parameter characterising the second-order fluids. It is found that in the region near the cylinder the stream lines of the secondary flow are closed loops while away from it they are U-shaped.

Chapter IV is concerned with the unsteady flow due to a rotating disk whose angular velocity is suddenly changed by a small amount proportional to ϵ , where $\epsilon << 1$. The unsteady equations are linearised with respect to ϵ using Von Karman solution as the non-zero mean. Separate solutions are developed for small and large time. It is found that the unsteady flow in the initial stages is of the Rayleigh type unaffected by the mean flow. The flow field then gets modified as a result of the diffusion of vorticity outwards. Strong interaction occurs between the steady mean flow and the superimposed flow which sets up damped torsional oscillations in the fluid.

Chapter V is devoted to the study of the flow due to an infinite plate moving with a uniform velocity in its own plane in an infinite liquid rotating with a time dependent angular velocity. In part one of this chapter, we consider the case when the angular velocity of the liquid consists of a weak oscillating component superimposed on a basic steady distribution. It is found that oscillations of $O(\epsilon)$ modify the steady mean flow (due to the rotation Ω_0 only), to $O(\epsilon^2\delta^2)$, where δ is the square of the ratio of the Ekman layer and the Stokes layer. In part two of the chapter is considered the case when the angular velocity is a slowly varying arbitrary function of time. Moore's method of series expansion is employed and the deviation of the actual instantaneous state of the flow from the quasi-steady state is determined. A simplified criterion $\dot{\Omega} \leq 0.4\,\Omega^2$ is established to define the conditions under which the flow can be considered as quasi-steady for the purpose of shear stress computations.

The last chapter is devoted to a study of the growth of boundary layer between two parallel walls due to the impulsive or uniformly accelerated motion of one of the walls under a uniform transverse magnetic field. The fluid is electrically conducting and a uniform suction or blowing is imposed on the moving wall. The study is restricted to small magnetic Reynolds number so that the induced magnetic field may be neglected, and the electric field is zero every where. Laplace Transform is used to find the velocity profile in the form of infinite series of error functions. Expressions for the skin-friction coefficient is obtained interms of two non-dimensional parameters, the Hartmann number M and the suction parameter S . The skin-friction is found to increase as M or S increases.