SYNOPSIS

The present thesis embodies a macroscopic analysis of the stability of an ionized plasma in the presence of magnetic field, the plasma being treated as hydrodynamic fluid interacting with electromagnetic forces under the approximations valid within the framework of magnetohydrodynamics. The well known normal mode technique is employed throughout the analysis to determine the characteristic modes leading to the stability or instability of the hydromagnetic systems. The investigations in the present dissertation, comprise of five chapters and mainly centre on two different types of problem, namely,

(i) The theory of superposed fluids,

(ii) Plasma in cylindrical configurations.

In Chapter I, a vivid picture of the subject of hydromagnetic stability towards its application in many physical phenomena supplemented by a historical background has been given. The various mathematical approaches for the determination of plasma stability characteristics and important roles of certain physical parameters have also been discussed.

In Chapter II, an attempt has been made to discuss the Helmholtz instability of a viscous compressible plasma, which is taken to be a perfect electrical conductor. Initially, the plasma is assumed to be in contact with an uniform magnetic field along a plasma boundary which is parallel to the field and it is further assumed to flow with uniform velocity V_0 perpendicular to the field. The linearized, homogeneous, algebraic equations have been solved to obtain the amplitudes of the perturbed quantities and dispersion equations have been derived. The analytical conditions for the validity of principle of exchange of stability and overstability have been discussed. Finally, the dispersion relations have been illustrated numerically in order to find the effects of viscosity and thermal conductivity (defined by the dimensionless parameters λ' and Υ') on the development of Helmholtz instability. The disturbance growth rate curves have been drawn, when no entropy producing agent is present and a comparative analysis shows that the effect of viscosity adds to the stability of the system.

A detailed investigation on the stability of a plane current-vortex sheet in an inviscid, perfectly conducting, compressible fluid has been made, in Chapter III. Using the appropriate boundary conditions, a tenth order dispersion relation has been derived and the significance of this relation has been discussed for several particular cases of interest such as large and small wavelength perturbations. For the general case, the analytical criteria for stability are derived using the properties of Hurwitz polynomial. Thus it has been found that the current-vortex sheet remains unstable if

$$A_0 < 0$$

where A_0 is a constant dependent on the physical parameters. It is found that for large Mach numbers and for magnetic pressure numbers which are greater than unity, the instability criterion

$$\lambda'^2 (1 + 2\vartheta_1^2 \sigma_2'^2 A_{H_2}^2) A_{H_1}^2 < (1 + 2\vartheta_2^2 \sigma_1'^2 A_{H_1}^2) A_{H_2}^2$$

is independent of Mach numbers. For a particular jet type flow of the fluid, it has been shown that the current vortex sheet is unstable to supersonic disturbances for sufficiently strong magnetic fields.

Chapter IV is concerned with the discussion of oscillations and stability of a plasma jet (which moves with uniform velocity) under the influence of axial magnetic fields. This chapter is devided into two sections:

A and B. In Section A, the study of plasma jet oscillations, whose natural frequencies are of the order of ion-cyclotron frequency, has been made including the effect of ion-cyclotron term in the generalized Ohm's law, while in Section B, the investigation is confined to the problem of finding the longitudinal oscillations of a cylindrical plasma jet (being immersed in another perfectly conducting plasma), which moves with the lines of force of an externally applied magnetic field (aligned to the jet). In both cases, generalized dispersion equations, taking the effects of compressibility and curvature (in a direction transverse to the velocity and magnetic fields) into account, have been derived, by matching the solutions in either of the media at the interface. In Section B, the stability criteria for the cylindrical current-vortex sheet to be stable have been obtained both for large and small wavelengths. It has been found, under certain approximations, that the current-vortex sheet is stable to supersonic disturbances (whose wavelengths are very large). For the fluids having identical acoustic and magnetic properties, it has been shown that the current-vortex sheet becomes unstable for increasing values of Mach numbers, when there is an unequal density distribution in either of the fluids. The results have been illustrated, numerically and stable values of the parameter Λ for both compressible and incompressible cases, have been tabulated. Finally, graphs have been drawn to show the regions of stability for both cases of compressibility and incompressibility.

In Chapter V, the stability of gravitating cylindrical plasma column subject to uniform volume and surface currents, has been investigated. Some general stability criteria have been illustrated for long and short wavelength perturbations. For long wavelength perturbations, the necessary and sufficient condition for stability has been shown to be

$$\frac{1}{b_1^2}\left(1-\frac{2b_2^2}{\lambda^2-1}\right)+\alpha_1^2+4\gamma\log\lambda < \frac{y\,I_0(y)}{I_1(y)}.$$

Also the general dispersion relations have been derived for the cases when (i) there are general magnetic field and current distributions and (ii) the system is subjected to an uniform and non-uniform angular velocity. It has been concluded that stability characteristics of the gravitating plasma is unaltered by the effect of uniform rotation in the case of axisymmetric disturbances whose wavelengths are assumed to be very large.