# PAPER –IV
# VISCOUS FLUID DYNAMICS

**TIME: 3 hours** **Max. Marks: 100**

## UNIT-I

Viscosity, Analysis of stress, Relation between stress and rate of strain, Navier-stokes equations and equation of energy in cartesian system of coordinates, vorticity and circulation. Reynolds law of similarity, Physical importance of non-dimentional parameters, Reynolds number Froude numbers, Mach number, Prandtl number, Eckert number.

## UNIT-II

Some exact solutions of Navier-stokes equations-steady, motion between parallel plates, Hagen poiseuille flow a circular pipe, flow between coaxial circular pipes, flow between two concentric rotating cylinders, Pulsatile flow between parallel surfaces, flow in convergent and divergent channels (Jaffery-Hamel flow),flow in the vicinity of stagnation point, unsteady motion of a plate.

## UNIT-III

Theory of very slow motion of a sphere in viscous fluid Osceen's improvement of stoke's theory. Boundary layer Theory: Boundary layer equations for two dimensional flows over a plane wall. Boundary layer on a flat plate (Blasius. Topper solution). Characteristic boundary layer parameters. similar solutions of the boundary layer equations.Exact solutions of the steady state boundary layer equation in two dimensional motion, Boundary layer along a flat plate.

## UNIT-IV

Flow past a wedge, Flow past a convergent channel. Boundary layer separation. Blasius series solution, Gortler,new series method. Prandtl-mises transformation, Axial symmetrical and three dimensional boundary layer: - Boundary layer on a Yawed cylinder. Approximate methods for the solution of the boundary layer equations Karman momentum integral equation, Karman-Pohlhousen method. Energy integral equations. Walz-Thwaites method based on energy integral equation.

## UNIT-V

Thermal Boundary Layer in Two Dimension Flow.

Thermal boundary layer equation for a plane wall. Forced convection in a laminar boundary layer on a flat plate (i) Crocco's first integral (ii) Reynolds's analogy (iii) Crocco's second integral for Pr =1. Free convection from a heated vertical plate: Thermal energy integral equation.Approximate solution of the Pohlhousen's problem of free convection from a heated vertical plate

**Book& Recommended:**


1. G.Schfichting : Boundary Layer Theory.
2. S.I.Pai : Viscous Flow Theory, Vol.I, Laminar flow.
3. J.L.Bansal : Viscous Fluid Dynamics.
4. M. D. Raisinghania : Fluid Dynamics.
5. Shanti Swarup : Fluid Dynamics.