1. (20%)

Discuss each of the following

(a) What is an inviscid flow?

(b) What is an irrotational flow? Can a viscous flow be irrotational? Can an inviscid flow be rotational?

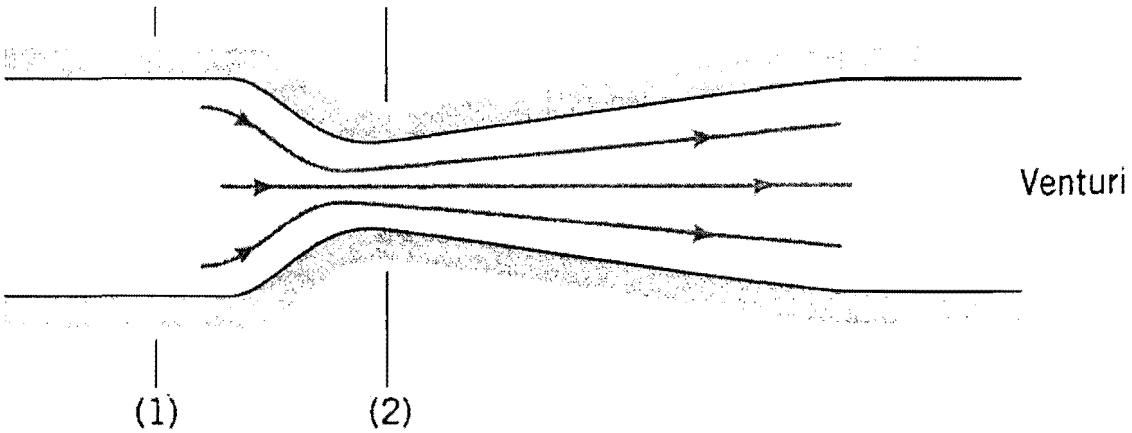
(c) What is a streamline, streakline, and a pathline?

(d) The velocity field for an irrotational, incompressible flow can be written in terms of a scalar potential. Give the mathematical expression for this relationship.

(e) How are the streamlines oriented relative the equipotential lines for a irrotational incompressible flow?

2. (20%)

A Venturi meter consists of a tapered constriction in a tube with pressure gauges to measure the pressures at positions (1) and (2).



Show that the flow rate for a fluid going down the tube is

$$Q = A_2 \sqrt{\frac{2\Delta p}{\rho\left[1-(A_2/A_1)^2\right]}}$$

Where Δp is the pressure difference between points (1) and (2) and A_1 and A_2 are the cross sectional areas at points (1) and (2) and ρ is the fluid density.

3. (20%)
The drag, D, on a washer shaped plate placed normal to a stream of fluid can be expressed as $D = f(d_1, d_2, \mu, \rho, V)$

where d_1 is the outer diameter, d_2 is the inner diameter, V the fluid velocity, μ is the fluid viscosity, ρ is the fluid density. Some experiments are to be performed in a wind tunnel to determine the drag. What dimensionless parameters would you use to organize these data.

4. (20%)
Answer as indicated :
(a) Explain the physical meaning of
(i) Reynolds number and
(ii) Froude number.
(b) (i) Write down the Navier-Stokes equation in vector form.
(ii) Explain the physical meaning of each term in (i).

5. (20%)
Consider two-dimensional laminar boundary-layer flow along a flat plate. Assume the velocity profile in the boundary layer is sinusoidal,
Find expressions for:

$$\frac{u}{U} = \sin(\frac{\pi}{2}\frac{y}{\delta})$$

(a) the rate of growth of δ as a function of x.
(b) the displacement thickness, δ^*, as a function of x.
(c) the total friction force on a plate of length L and width b.