(10%)1. Does the surf on a beach represent (a) steady or unsteady flow, and (b) uniform or non-uniform flow? Why?

(10%)2. If the flow pattern for efflux from a given orifice is known, how may it be used to analyze the efflux from an orifice which has the same proportions but is ten times as great in size?

(10%)3. Why can fluid weight have no influence upon the flow pattern if the fluid is fully confined by fixed boundaries?

(10%)4. Under what circumstances can a wave or surge move upstream against the oncoming flow. Why?

(10%)5. Show that the Reynolds number may be considered to represent the ratio of a typical inertial reation to a typical viscous force.

(20%)6. The results of a wind tunnel test to determine the drag on a body (see Fig.1) are summarized below. The upstream [section (1)] velocity is uniform at 100 ft/s. The static pressures are given by $p_1 = p_2 = 14.7$ psia. The downstream velocity distribution, which is symmetrical about the centerline, is given by

$$u = 100 - 30\left(1 - \frac{|y|}{3}\right) \qquad |y| \le 3\,\text{ft}$$
$$u = 100 \qquad |y| > 3\,\text{ft}$$

where u is the velocity in ft/s and y is the distance on either side of the centerline in feet (see fig. 1). Assume that the body shape does not change in the direction normal to the paper. Calculate the drag force (reaction force in x direction) exerted on the air by the body per unit length normal to the plane of the sketch.

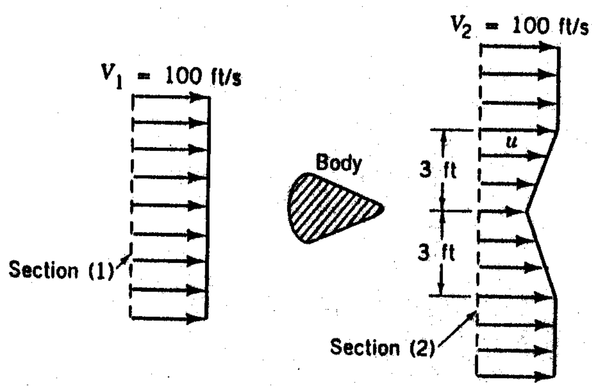

Fig.1

(10%)7. A fluid flows at a velocity V through a horizontal pipe of diameter D. An orifice plate containing a hole of diameter d is placed in the pipe. It is desired to investigate the pressure drop, Δp, across the plate. Assume that

$$\Delta p = f(D, d, \rho, V)$$

where ρ is the fluid density. Develop a set of dimensionless parameters that can be used to investigate this problem.

(20%) 8.Consider turbulent flow of an incompressible fluid past a flat plate. The boundary layer velocity profile is assumed to be

$$u/U = (y/\delta)^{1/7} = Y^{1/7} \text{ for } Y = y/\delta \le 1 \text{ and } u = U \text{ for } Y > 1$$

as shown in Fig. 2. This is a reasonable approximation of experimentally observed profiles, except very near the plate where this formula gives $\partial u/\partial y = \infty$ at y=0. Note the differences between the assumed turbulent profile and the laminar profile.

Also assume that the shear stress agrees with the experimentally determined formula:

$$\tau_w = 0.0225 \rho U^2 \left(\frac{\nu}{U\delta}\right)^{1/4}$$

Determine the boundary layer thicknesses δ, δ^*, and θ and the wall shear stress, τ_w, as a function of x. Determine the friction drag coefficient, C_{Df}.

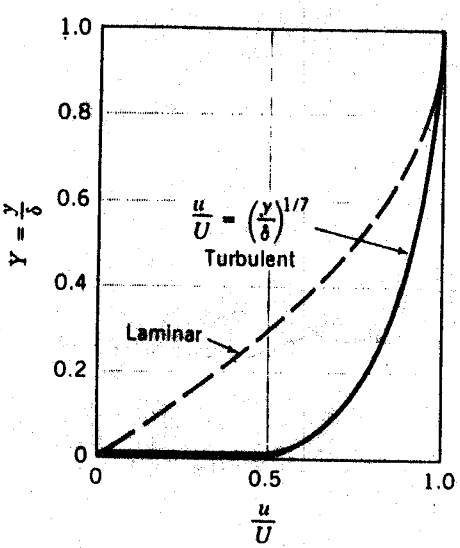

Fig. 2