Problem 1 (20%)

What is the Archimedes' Principle? Consider a body of arbitrary shape, having a volume V, that is immersed in a fluid having a constant specific weight γ as illustrated in Fig. 1(a). We enclose the body in a parallelepiped and draw a free-body diagram of the parallelepiped with the body removed as shown in Fig. 1(b). Note that the forces F_1, F_2, F_3, and F_4 are simply the forces exerted on the plane surfaces of the parallelepiped (for simplicity the forces in the x direction are not shown), W is the weight of the shaded fluid volume, and F_B is the force the body is exerting on the fluid. Determine the magnitude and the direction of the buoyant force acting on the body, and the point (y_c) through which the buoyant force acts.

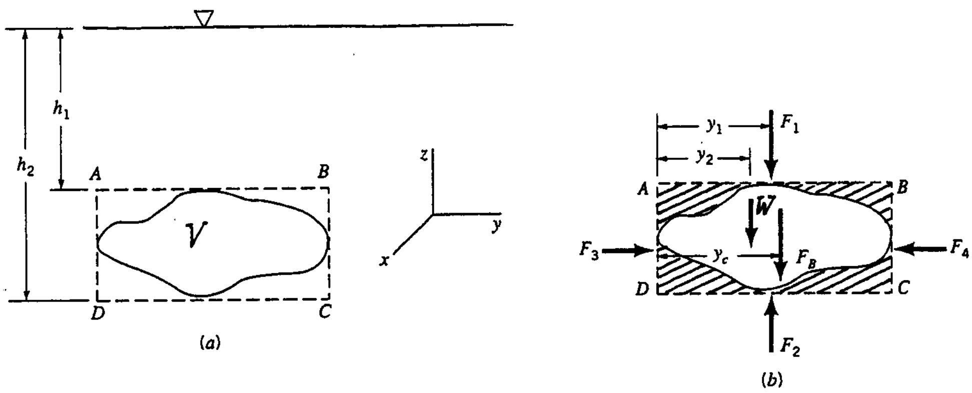

Figure 1

Problem 2 (12%)

Considering a single stream fluid between two sections of ① and ②, write down

(1) the one-dimensional steady-flow energy equation for incompressible flow, and

(2) the Bernoulli equation for inviscid flow, and then

(3) compare the above two equations to define (and explain) the useful energy (or the so-called available energy) and the loss of useful energy because of friction.

Problem 3 (18%)

(1) What are the free vortex and the forced vortex? Give examples to explain. Which one (or both) is a rotational flow? Explain the physical meaning.

(2) What are streamlines, streaklines, and pathlines? Give examples to explain. In what situation, streamlines, streaklines, and pathlines are the same?

(背面仍有題目,請繼續作答)

Problem 4 (15%)

The drag, $\mathscr{D}$. on a sphere located in a pipe through which a fluid is flowing is to be determined experimentally (see Fig.4). Assume that the drag is a function of the sphere diameter, d, the pipe diameter, D, the fluid velocity, V, and the fluid density, ρ . **(a)** Determine the dimensionless parameters you use for this problem. **(b)** Some experiments using water indicate that for d=0.2 in., D=0.5 in., and V=2 ft/s, the drag is 1.5×10^{-3} lbf. If possible, estimate the drag on a sphere located in a 2-ft-diameter pipe through which water is flowing with a velocity of 6 ft/s. The sphere diameter is such that geometric similarity is maintained.

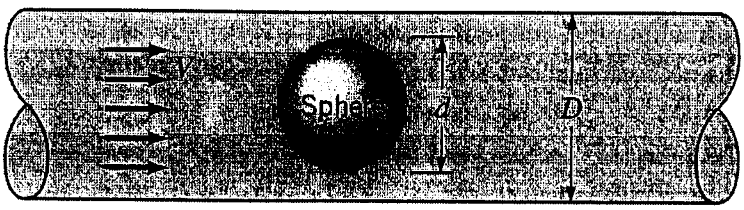

Fig.4

Problem 5 (15%)

A horizontal pipe of 7.5 cm diameter is joined by a sudden enlargement to a pipe of 15 cm diameter (see Fig.5). Water is flowing through it at a rate of 0.1414 m^3/s. If the pressure just before the junction is 6 m head, what will be the pressure head in the 15 cm pipe downstream of the junction? What will be the power loss at the junction?

p: pressure
v: flow velocity
a: area of cross section

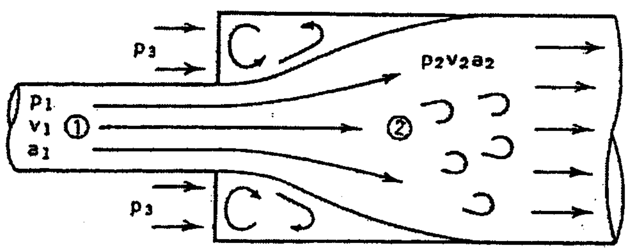

Fig.5

Problem 6 (20%)

Using a cubic profile $\alpha y+\beta y^3$ for the laminar boundary layer, determine α and β and find δ/x by using the von Kármán momentum integral equation for a flat plate with a zero pressure gradient; where $\delta(x)$ denotes the boundary layer thickness.