Dimensional analysis

1. A large water tank empties slowly through a small hole under the action of gravity. The flow is steady, and the mass flow rate m depends on the exit velocity V, the gravitational acceleration g, the depth of the water h, ,the diameter of the nozzle D, the viscosity μ, and the surface tension σ (force/length).
   a) Express the nondimensional mass flow rate in terms of its dependence on the other nondimensional groups
   b) If the experiments were to carried out using water in a 1/5 scale model:
      i. What is the ratio of the model flow rate to prototype mass flow rate that would be needed to obtain dynamical similarity?
      ii. Do you anticipate any difficulties in obtaining full dynamical similarity?

Boundary Layer and drag

1. for the boundary layer velocity profile given by:

   $u/U_\infty = y/\delta$, $(y<\delta)$

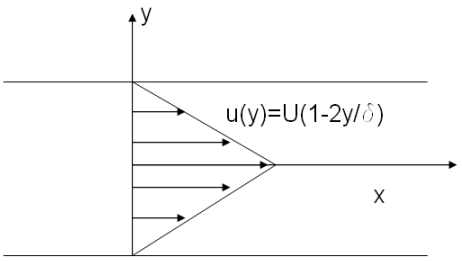
   (a) find the wall shear stress, the skin friction coefficient, the displacement thickness and momentum thickness

   (b) find the relationship between δ/x and Re_x.

2. a skydiver of mass 75kg is falling freely. If his drag coefficient is 1.2 and his frontal area is $1m^2$, find his terminal velocity, assuming the air temperature is 10℃. ($Cd=D/(0.5\rho U^2)/A$)

Flow in a conduit

1. Consider fully developed, steady flow of a constant density Newtonian fluid in a circular pile of diameter D
   a) Show the pressure gradient $dp/dx=-4\tau_w/D$, where τ_w is the viscous shear stress on the wall
   b) If the velocity distribution is triangular as shown in the figure below, find the average velocity V at any cross section , and express the skin friction coefficient ($Cf= \tau_w /0.5\rho V^2$) in terms of the Reynolds number ($Re=VD/\nu$).



2. Water flows through a 100 meter long pipe with a diameter of 5cm and a flow rate of 0.01m^3/s. if the friction factor for the pipe is f=0.04, compute the pressure different at the two ends of the pipe. (pressure drop along a pipe is given by $\Delta p=f(L/D)(0.5\rho V^2)$.)

The assignments above are due on Dec 27. 2012

The assignment below is due on Jan. 18, 2013

Turbulence

Download and install a trail copy of CFD package FLUENT, compare the drag coefficients of a smooth cylinder and a rough cylinder (ε/D=0.05) at a Reynolds number of 10000. Compare the results given by different turbulence models. Mail a digital copy of your report to gaonan @ dlut.edu.cn, include as much analysis and discussion in your report as possible. Plagiarism will be prosecuted.

这里 ε 指的是粗糙元的高度