Fluid Dynamics

2013 Final Exam.

2013. 6. 14

1. A two-dimensional velocity field is given by

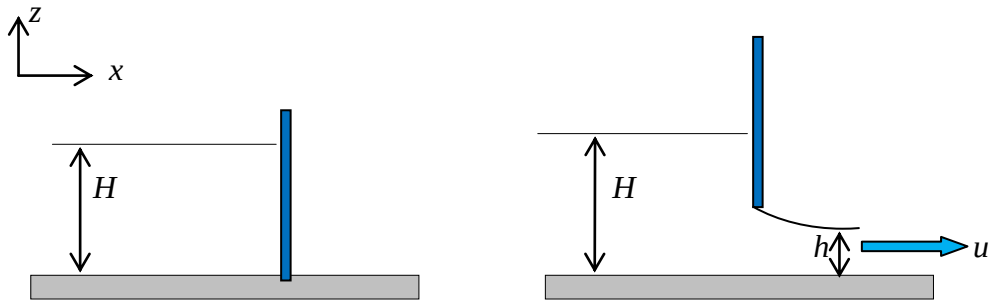
$$\vec{q} = \left(x^2 - y^2 + x\right)\vec{i} - \left(2xy + y\right)\vec{j}$$

in arbitrary units. At $x = 2$ and $y = 1$ compute

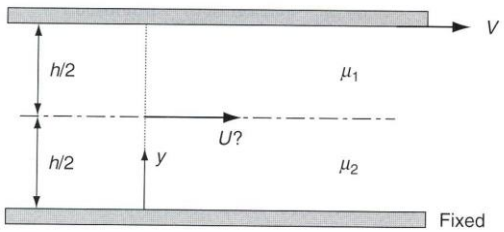
a) the accelerations a_x and a_y

b) the acceleration component parallel to the velocity vector

2. A sluice gate across a channel of width *b* is shown in the closed and open positions in the figure given below. Find the equation for the force exerted by water to the gate. Is the anchoring force required to hold the gate in place larger when the gate is closed or when it is open?



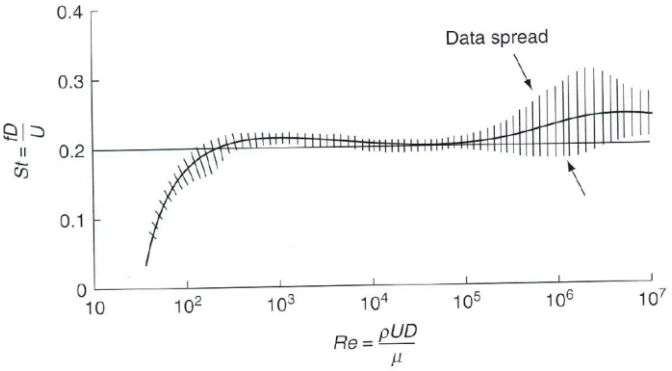
3. Equal layers of two immiscible fluids are being sheared between a moving and a fixed plate, as in figure below. Assuming linear velocity profiles, find an expression for the interface velocity *U* as a function of *V*, μ_1, and μ_2.



4. The vortex shedding behind a circular cylinder is one of many viscous flows which, though posed with fixed and steady boundary conditions, evolve into unsteady motions because of flow instability. Measured Strouhal number for vortex shedding frequency is plotted against Reynolds number in the following figure. Here Strouhal number, *St*, is defined as

$$S_t = \frac{fD}{U}$$

where f = shedding frequency; D = diameter of the circular cylinder; U = approaching velocity. Based on this figure, sketch diagrams of vortex shedding phenomena behind a circular cylinder for Re = 50, 100, 200, 500, 1,000 when U = 1 m/s.



5. Reynolds equation can be derived from the Navier-Stokes equation for incompressible fluid flow.

a) Write down 3D Reynolds equation and Navier-Stokes equation, and explain each term of two equations. Compare two equations.

b) Why do we need to add some turbulence models to solve the Reynolds equation?

c) Describe briefly about zero-equation models among various turbulence models and discuss merits and de-merits of each model.