1. An illustrative example for the hydraulic design on the basis of the distribution of residence time t_s (the throughflow wave) is presented in Fig 1. t_f is the average of the residence time. Alternatives 1-4 were run to assess the effects of the direction of the rotation of the mixer, while alternatives 5-9 included the diversion walls (隔板) with different perforations (孔洞). Please answer following questions according to those results.

① In these ten cases, which can occur considerable short-circuiting and which was least disturbed by the short-circuiting ? (4 points)

② How is the effect of the direction of mixer on the throughflow wave? (4 points)

③ Which case is the most ideal reactor ? (4 points)

④ On the basis of your operational experience, which case is favorable to you ? Specify your reason. (4 points)

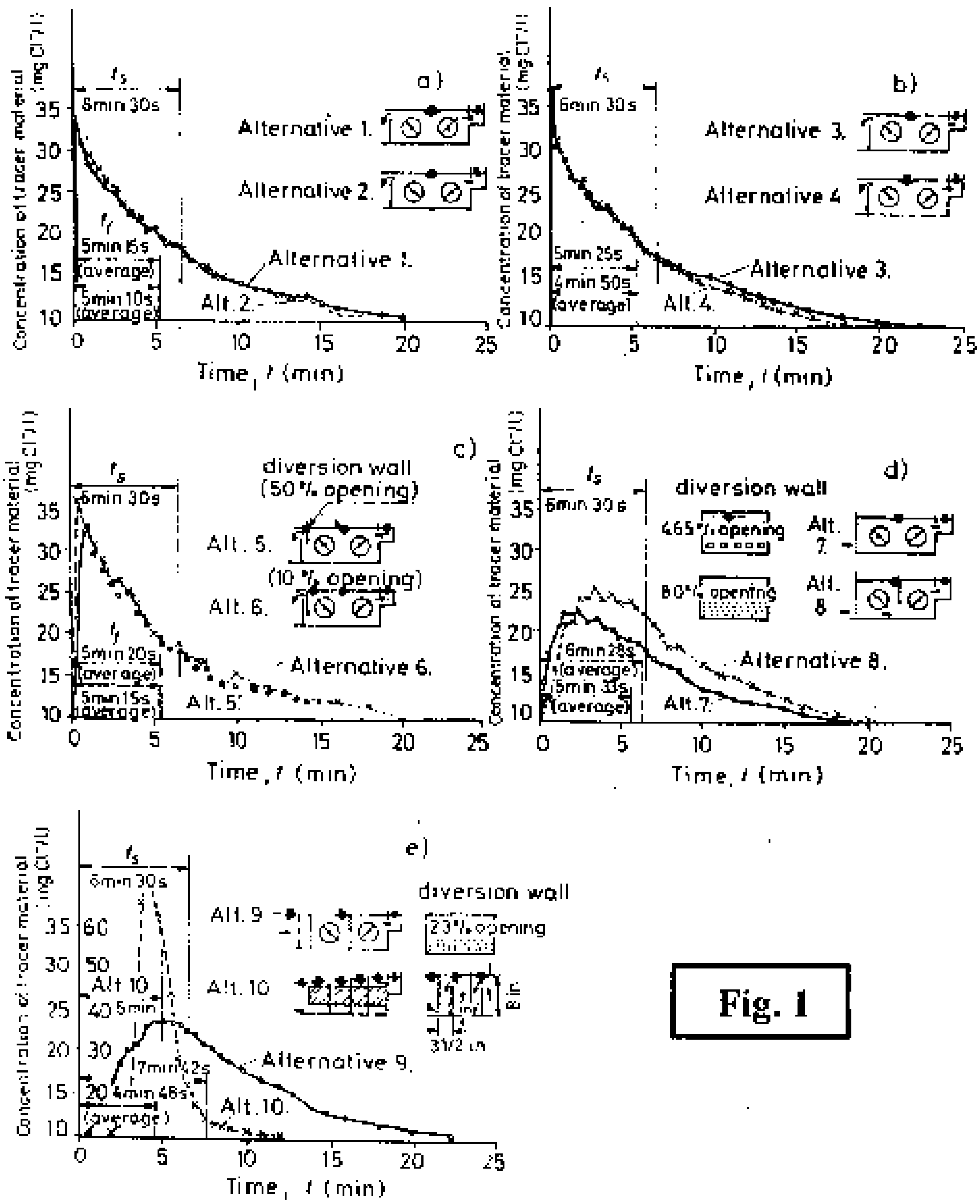


Fig. 1

2. Identify the following terms in each item and explain their relationship. (18 points)
   ① Rheology and non-Newtonian fluid
   ② Turbulent Shear Stress, Dynamic Eddy Viscosity and Kinematic Eddy Viscosity
   ③ Dynamic Similarity and Reynold Number

3. What horsepower must be supplied to the water to pump 2.5 cfs from the lower to the upper reservoir as shown in Fig. 2? Assume that the head loss in the pipes is given by $h_L = 0.015\,(L/D)(V^2/2g)$, where L is the length of pipe in feet and D is the pipe diameter in feet. (8 points)

4. If a fluid is inviscid (an ideal fluid) and if the flow of such a fluid is initially irrotationa then the flow will be irrotational throughout the entire flow field. The flow pattern of irrotational flow past a cylinder is shown in Fig 3. Please qualitatively describe how the fluid travels from one point to another (A→E) with the viewpoints of velocity and pressure. (8 points)

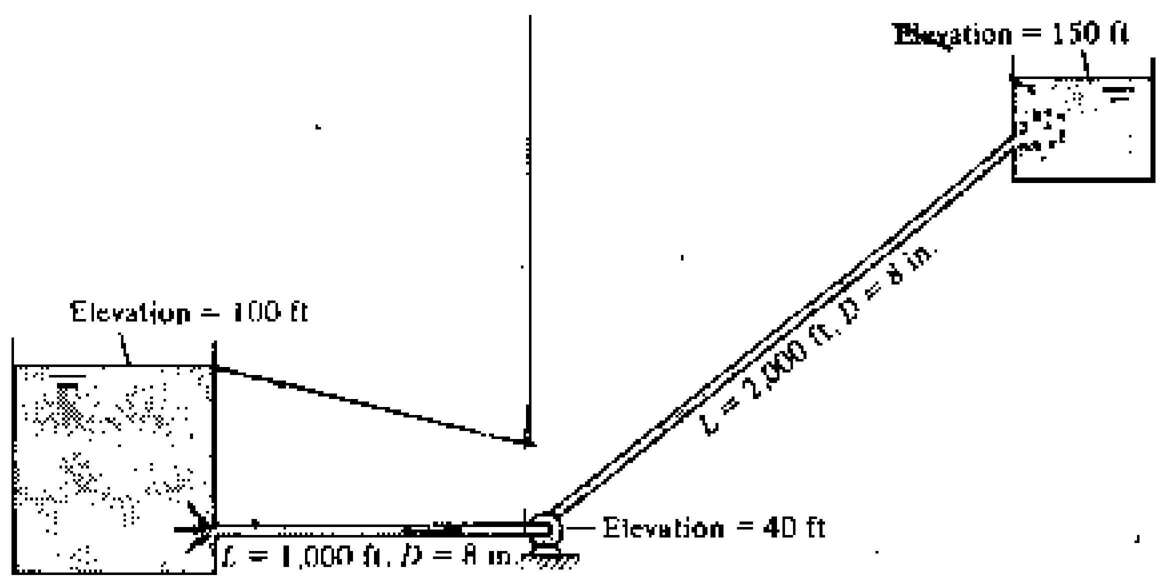


Fig. 2

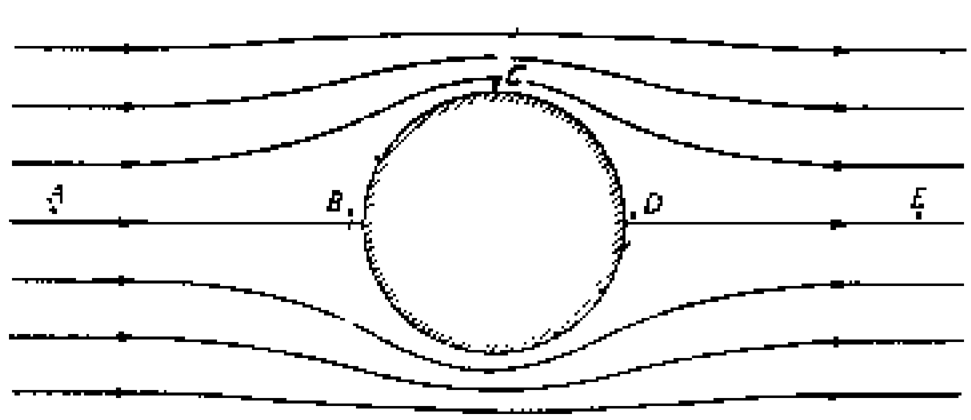
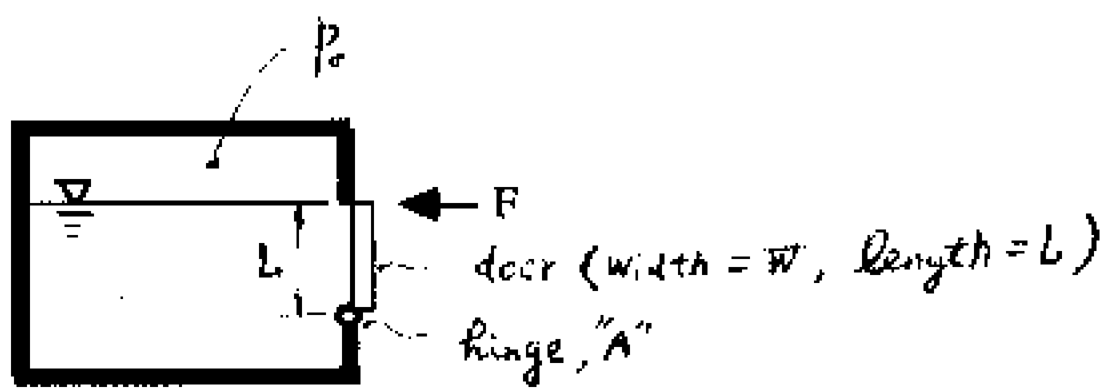


Fig. 3

5.



(12 %) As shown in the above figure, the door is hinged at point "A" along its bottom on the right-hand side of the water tank. Air pressure P_o (in gauge pressure) is applied to the water free surface. Find the force F that is required to hold the door shut.

6. Answer the following questions regarding to the differential equation for the conservation of mass in cylindrical coordinates. V_r, V_θ, and V_z are the velocity components in the r, θ, and z directions respectively.

(i) (3 %) Draw differential control volume in cylindrical coordinates.

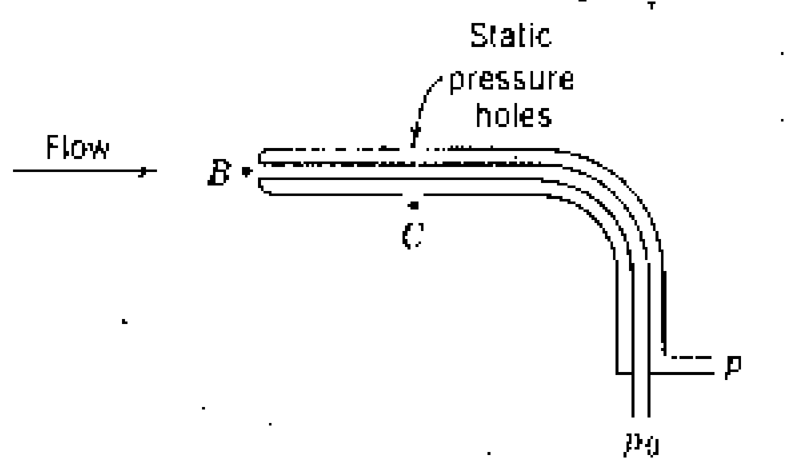
(ii) (3 %) Write down mass efflux through each control surface.

(iii) (3%) Write down the rate of change of mass inside the control volume.

(iv) (3%) Write down the mass conservation equation in cylindrical coordinates.

7. (i) (6 %) Calculate air density at 35 °C, 1 atm, using ideal gas law. Universal gas constant R = = 8.314 joules/°K–mole; molecular weight of air M_w = 28.9 g/mole; 1 atm =1013.3 mb ;1 mb = 100 Pa)

(ii) (6 %) Pitot–static tube shown below is often used by an engineer to measure air flow velocity. The inner tube is used to measure the stagnation pressure at point B (denoted as P_o), while the static pressure at C (denoted as p) is sensed by the small holes in the outer tube. If the pressure difference between P_o and P is 20 mm of mercury at 35 °C, 1 atm, what is the air flow velocity.



Pitot–static tube

8. (i) (7%) What is the control volume formulation of Newton's second law for a nonaccelerating control volume. Write it down in vectorial form.

(ii) (7%) Water jet from a stationary round nozzle strikes a fixed vertical flat as shown below. Calculate the horizontal force in kN and bending moment in kN–m on the support. Assuming the water flow rate is 100 liters per second, nozzle diameter is 7 cm, and the water is directed normal to the plate.