2021 ENTRANCE EXAMINATION FOR INTERNATIONAL MASTER'S PROGRAM
Departments of Mechanical Engineering and Hydrogen Energy Systems

Fluids Engineering (Group A) [10:45~12:15]

Question I

Water is ejected horizontally into the atmosphere through an L-shaped circular-pipe with the small diameter, as shown in Fig. 1. The pipe is installed along the Axis 1 in the vertical direction. The upper exit of the pipe is open to the atmosphere whose pressure is P_A. The bottom entrance is under the surface level of the water in a huge closed-tank where the pressure of the accumulated air is controlled as P_T. The upper exit of the pipe is shielded by the lid which has a small hole at the center. The area of the small hole is sufficiently small against the cross-sectional area of the pipe. The pipe is rotating with a constant angular velocity of ω around the Axis 1. The length of the horizontal part of the pipe is L, and the height from the water surface in the tank to the Axis 2 is H. The flow rate exiting through the small hole of the pipe is so small that the through-flow rate inside the pipe is negligible. The density of water and the acceleration of gravity are denoted by ρ and g, respectively. Express the velocity of exiting flow from the small hole U by ω, H, L, P_A, P_T, ρ and g. (30 Points)

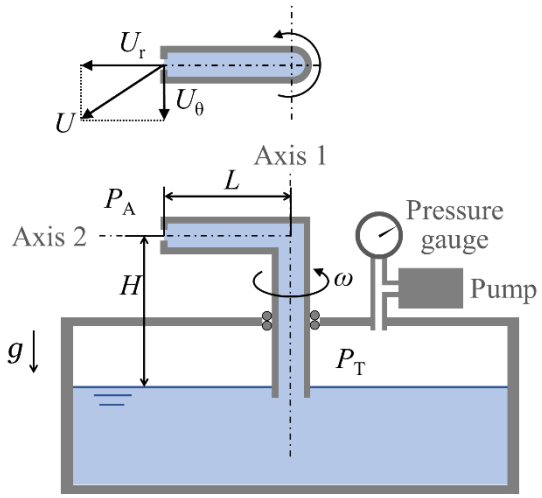

Figure 1

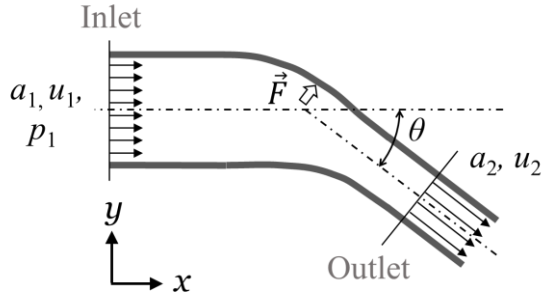

Figure 2

Question II

Water is flowing in a pipe bend whose cross-sectional area is narrowed from a_1 at its inlet to a_2 at its outlet. The flow is bent with an angle θ, as shown in Fig. 2. The bend is located in a horizontal plane. The velocities at the inlet and the outlet are u_1 and u_2, respectively. The gauge pressure at the inlet is p_1 and the density of water is ρ. The flow is assumed to be uniform at each cross-section and the friction loss in the pipe is negligible. Taking the coordinates x and y as shown in Fig. 2, express F_x and F_y which are the components in x and y directions of the total force acting on the inner surface of the bend by ρ, a_1, a_2, u_1, p_1, and θ. (20 Points)