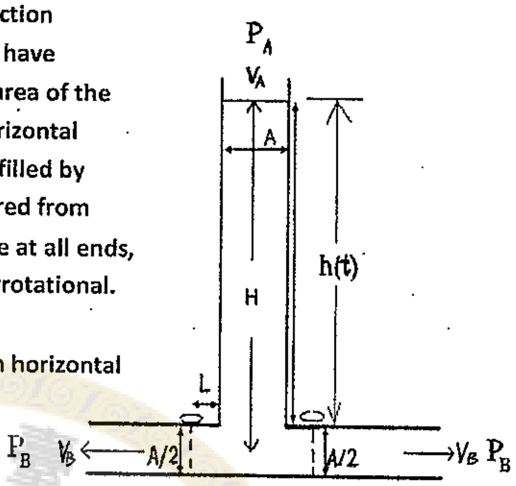
Problem 1. (20%) A vertical tube of small constant cross section divides at the lower end into two horizontal tubes. All tubes have circular cross section. The area of the vertical tube is A; the area of the horizontal tubes is A/2. There are two valves shut off the horizontal tubes. Initially, the valves are closed and the vertical tube is filled by incompressible fluid of density ρ to a height H. (H is measured from free surface to the centerline of horizontal tube)The pressure at all ends, P_A and P_B, are atmospheric pressure. The flow is inviscid irrotational. At t=0, both valves are opened simultaneously.

Hint: Assume the tube diameter and the initial fluid length in horizontal tube, L, are both negligible compared to H

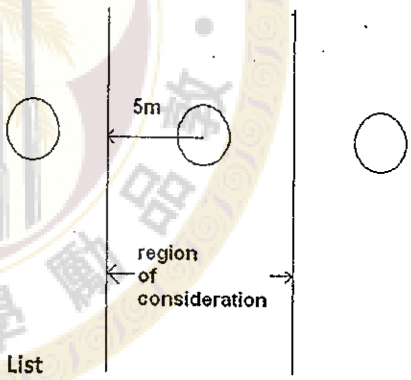


(a) (6%) List the equations that you can use. (Give reasons)

(b) (10%) Fluid depth of the vertical pipe is denoted as h(t). Solve h(t). Also calculate the velocities V_B. (Hint: h(0)=H)

(c) (4%) Determine the time when vertical tube has no fluid.

Problem 2. (20%) A new bridge is to be built on a wide river. The diameter D for the cross section of cylindrical piers is 1m. The distance between the centers of adjacent piers S is 10m. The river width W is 100m and flow depth h is 5m. The flow velocity V is 0.5m/s. Now we use a length ratio L_{field}/L_{lab}=50 to build a model in laboratory. However, in the laboratory experiment, we consider only one pier, the setup is depicted in fig. The fluid used is mercury ($\rho_{mercury}/\rho_{water}$=13.6, and $\nu_{mercury}/\nu_{water}$=2). The measured impact force on the piers in lab is 10NT for the whole model pier.



(a) (6%) List all variables that you think are related to this problem. List these variables under three different groups: Material characteristic, shape, force. You should list at least 6 variables and explain why they are relevant. (Note: No explanation, no point)

(b) (8%)Find the number of π terms and list the repeating variables. Then find all the dimensionless variables

(c) (6%) What flow velocity for this laboratory experiment should be? What is the impact force for the real pier? Explain if there will be any difficulty in completing this experiment.

見背面

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Problem 3. (40%) A pipe connects two small reservoirs. The pipe diameter is 1m, pipe length is 500m and the pipe friction factor is 0.02. The area of reservoir A and B are 10000 m^2 and 5000 m^2, respectively. The initial elevation difference between two reservoirs is 16m (let gravity $g=10m/s^2$)

Assume the inflow from pipe to reservoir is negligible for the following problems (a) , (b) and (c)

(a)(15%) Calculate the inflow rate of the pipe.

(b) (5%) What is magnitude and location of the maximum pressure on pipe. ($\sin\theta = 0.04$)

(c) (5%) If a huge rock with density 0.95 and 10000m^3 volume falls into reservoir A, what is the inflow rate?

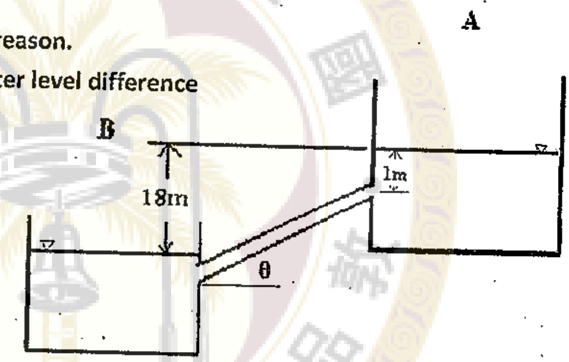
(d) (5%) Is the assumption negligible inflow rate reasonable? Give your reason. (No reason, no point)

Now do not assume the inflow rate is negligible for the following (the initial condition is the same as in figure)

(e) (10%) There is a heavy rainfall of 50cm/Hr in the area of reservoir A. As rain goes into reservoir A, water level in reservoir A increases and flow rate in the connecting pipe increases. But as water flows Into reservoir B, water level in reservoir B will increase. This decreases the flow rate in the connecting pipe. Will this situation eventually reach a steady state? (steady state means the flow rate at the connecting pipe will not change in time)

If you think there will be no steady state, give your reason.

If you think there is a steady state, give the final water level difference



Problem 4. (20%) A vertical rectangular tube is filled with water. Water depth is 2m as shown. There is a hole I at the center of surface ABCD with diameter 10cm.

(a) (10%) If hole I is closed, water is quiescent is the tube. Calculate the total force on surface ABCE+CDEF+EFGH. (magnitude and direction)

(b) (10%) If hole I is now opened, calculate the force on surface ABCD (assume the outflow does not change the free surface elevation)