NATIONAL EXAMINATIONS DECEMBER 2002

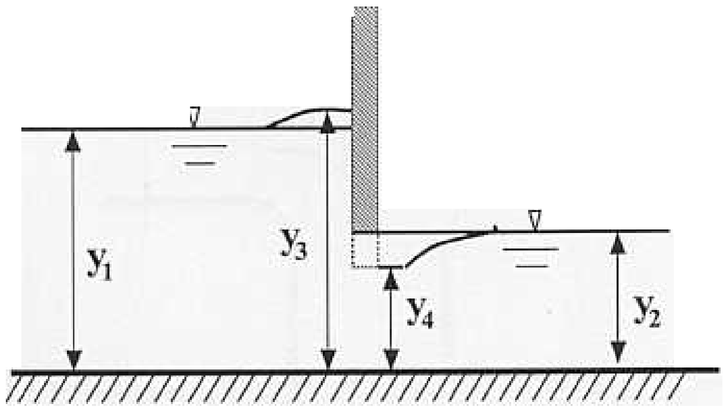
98-Civ-A5, Hydraulic Engineering

3 Hours Duration

NOTES:

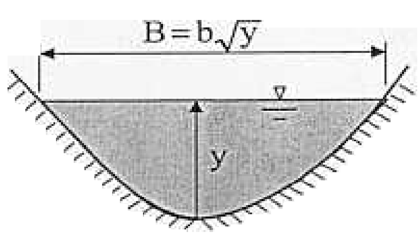
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.
2. CLOSED BOOK Examination. However, the following are permitted:
   - ONE $8\frac{1}{2} \times 11$ inch aid sheet (both sides may be used); and
   - Candidates may use one of two calculators, a Casio FX-991 or Sharp EL-540.
3. This examination has **seven** questions, of which **any five** are required to be completed. Indicate clearly on your examination answer book which questions you have attempted. Only the first four questions as they appear in your answer book will be marked. All questions are of equal value. If any question has more than one part, each part is of equal value.
4. Note that 'cms' means cubic metres per second; 1 inch 2.54 cm.
5. The following equations may be useful:
   - Hazen-Williams: $Q = 0.278CD^{2.63}S^{0.54}$, $S = \Delta h/L$
   - Darcy-Weisbach: $\Delta h = \frac{fL}{D} \cdot \frac{V^2}{2g} = 0.0826\frac{fL}{D^5}Q^2$
   - Loop Corrections: $q_l = -\frac{0.54\sum_{\text{loop}} \Delta h_i}{\sum_{\text{loop}} |\Delta h_i / Q_i|}$
   - Node Corrections: $\Delta H_n \quad \frac{\sum_{\text{node}} Q_i}{0.54\sum_{\text{node}} |Q_i/\Delta h_i|}$
6. Unless stated to the contrary, (i) assume that local losses and velocity head are negligible, (ii) that the given values for pipe diameters are nominal pipe diameters and (iii) that the flow involves water with a density $\rho = 1000$ kg/m^3.

In the 1.0 m wide rectangular channel shown below, the original upstream depth y_1 is 2.0 m, the original downstream depth is $y_2 = 1.0$ m and the flow 1.0 m^3/s. This discharge is suddenly decreased by 50%, creating two surge waves that propagate upstream and downstream from the gate. Estimate the height of both surge waves y_3 and y_4 and their associated speeds of propagation.

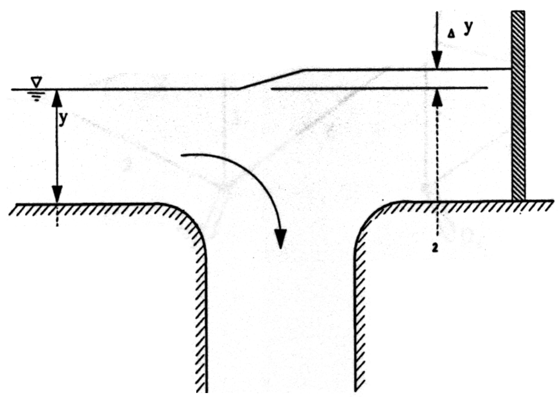


2. Many human activities create changes in both the hydraulic and the thermal condition of streams, rivers and lakes. Discuss briefly the range of the temperature or thermal changes associated with a stream that flows through (and drains) an urban area. Briefly discuss the significance that these changes might have on both the stream itself and on the lake into which it discharges immediately downstream of the urban area.

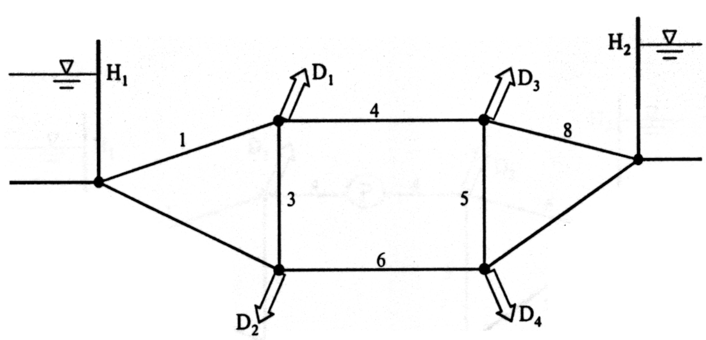
3. A natural river bed has a section that is approximately parabolic, such that its surface width is 50 m when the center depth is 2 m. If $n = 0.025$, find the center depth when the discharge is 40 m^3/s and the slope is 1 m per kilometre. Also find the flow when the depth associated with 40 m^3/s is doubled. (Assumed $P \approx B$.)



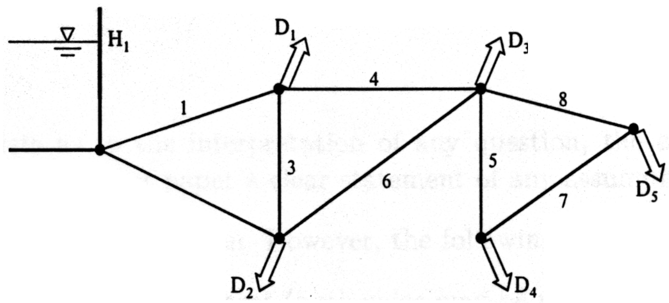
4. As shown in the figure, water flows at a depth y and velocity v in a rectangular channel which is blocked downstream by a closed gate. However, the water flows smoothly down into a vertical shaft. Calculate the rise Δy (assumed $\Delta y << y$) in the water surface just upstream of the closed gate using both the energy and momentum equations. Do the answers agree? If not, which answer is correct, and why?



5. All eight pipes shown below have a length of 400 m, a diameter of 0.610 m, and a Hazen-Williams C value of 120. All four demands shown are 0.6 m^3/s. The reservoir levels are $H_1 = 120$ m and $H_2 = 135$ m and all pipes are installed at the elevation of the datum. Determine the flow in each pipe and the minimum pressure head in the system.



6. All eight pipes shown below have a length of 500 m, a diameter of 0.357 m, and a Hazen-Williams C value of 130. All five demands shown are 0.1 m^3/s. The source reservoir level is $H_1 = 105$ m and all pipes are installed at the elevation of the datum. Determine the flow in each pipe and the minimum pressure head in the system.



7. All seven pipes shown below have a length of 1000 m, a diameter of 0.610 m, and a Darcy-Weisbach f value of 0.015 (assumed constant). The two demands shown are 0.25 m^3/s. The reservoir levels are $H_1 = 100$ m and $H_2 = 130$ m and all pipes are installed at the elevation of the datum. Determine the flow in each pipe. A pump, at the midpoint of pipe 4, pumps from left to right and has a head-discharge curve given by

$$H_p = 50 - 300Q^2$$

where H_p is the total dynamic head of the pump (m), and Q is the flow through the pump (m^3/s).