NATIONAL EXAMINATIONS—MAY 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 **six** questions, of which **any four** 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.

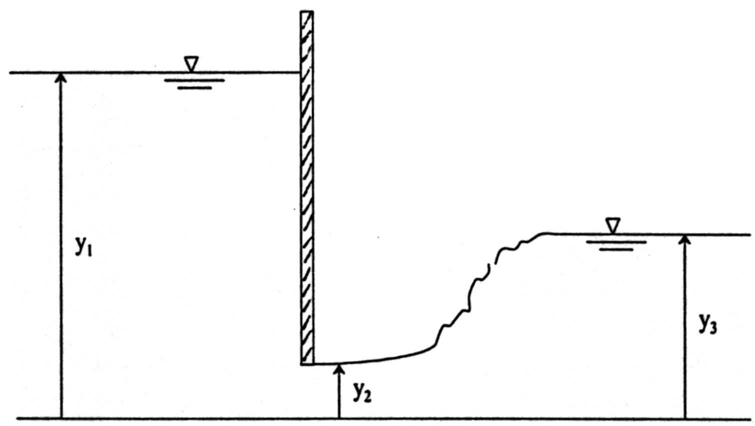
4. Note that 'cms' means cubic metres per second; 1 inch = 2.54 cm.

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: $\Delta H_n = \frac{\sum_{\text{node}} Q_i}{0.54 \sum_{\text{node}} |Q_i/\Delta h_i|}$

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 that (iii) the flow involves water with a density $\rho = 1000$ kg/m^3.

1. In the hydraulic system shown below, the upstream depth y_1 is 5 m and the intermediate depth of $y_2 = 1.0$ m. Ignoring friction in the channel and losses at the gate, estimate the discharge per unit width of channel, the depth after the hydraulic jump y_3 and the energy loss in the jump (in m). If the channel and gate are both frictionless, why is there still an energy loss in the hydraulic jump?



2. Many hydraulic structures—including dams, spillways, and channel diversions—are installed and motivated by their hydraulic benefits. However, the same structures can also cause significant disruption to the stream or river ecology, to the local environment around the stream, and may also cause a number of hydraulic complications.

   For any **one** of the three mentioned structures, discuss some of the key benefits associated with their installation, and also some of the most important environmental challenges associated with their presence in a stream or river system.

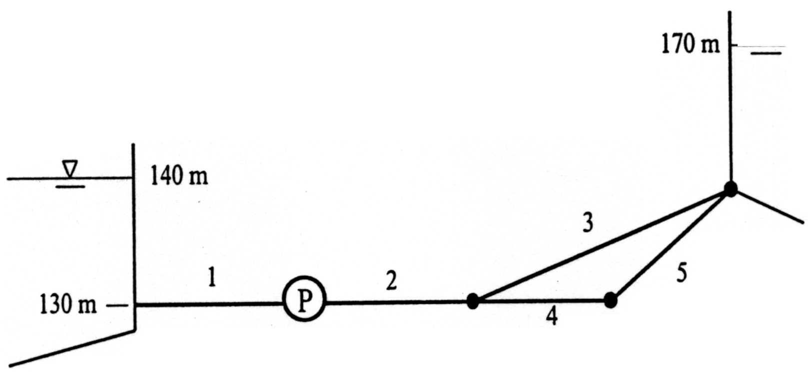
3. A rectangular open channel section is 4 m wide and carries a flow of 4.0 m^3/s. The longitudinal profile of the bed is a length of constant slope 0.028 followed by a short length of horizontal channel. Downstream of the horizontal reach is a long length with a slope of 0.028. The channel has a Mannings n of 0.018. Being quantitative where the data allows, sketch one of the possible water surface profiles along the channel.

4. The pump in the 5 pipe system shown in the sketch below (not to scale) has a characteristic curve given by

$$H_p = 50 - 250Q_p^{1.85}$$

where H_p is the total dynamic head of the pump in m and Q_p is the pump discharge in cubic metres per second. The water is being pumped between the two indicated reservoirs from left to right (i.e., from the 140 m reservoir to the 170 m reservoir).

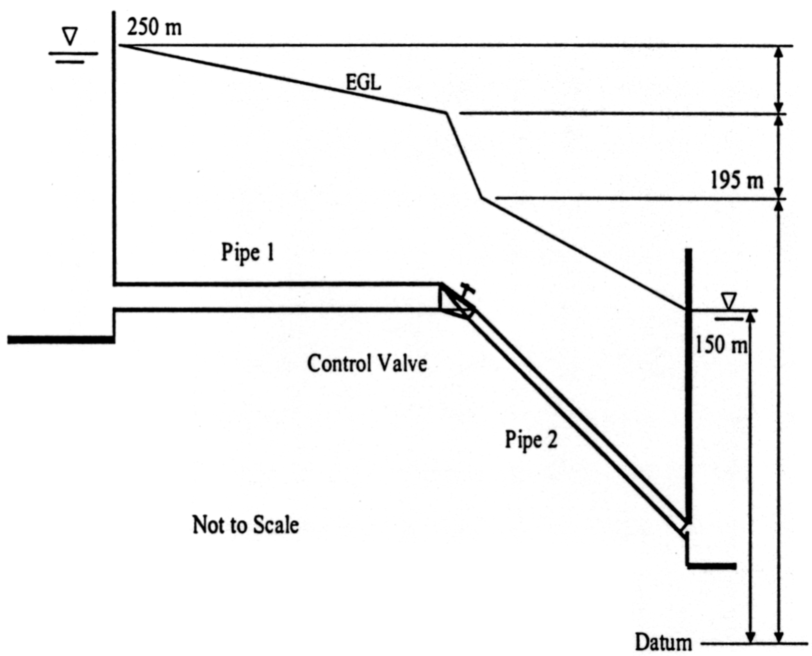
Each pipe is 0.347 m in diameter and has a Hazen-Williams C factor of 130. Pipes 1, 2 and 5 are all 1000 m long, pipe 4 is 700 m long, and pipe 3 is 1200 m long. (a)Determine the flow in each pipe and the total dynamic head being produced at the pump. (b) Estimate the NPSH available at the pump. (The water has a vapour pressure of 1500 Pa and atmospheric pressure is 98.0 kPa.)



5. A pipe system has a control valve at the junction of two pipes. The upstream pipe is 0.305 m in diameter, 7000 m long, and has an estimated Darcy-Weisbach friction factor of $f = 0.021$. The downstream pipe is 0.254 m in diameter, 6600 m long and has a $f = 0.024$.

   Flow is supplied at the upstream end from a large reservoir that is at a fixed elevation of 250 m and the pipe exits at the downstream end into another reservoir at an elevation 150 m. The downstream end of the control valve has a known head of 195 m.

   (a) Determine the flow in the system and the head loss across the control valve. (b) Assuming the wavespeed of both pipes in the system is 1200 m/s, estimate both the upstream and downstream total head that will be occur immediately after the control valve is suddenly and completely closed from the starting condition determined in (a).



6. In the system shown below, all eight pipes are 0.488 m in diameter, have a $C = 120$, are 1200 m long and constructed at a 220 m elevation. The total head at the source node (node 100) is 300 m. The demand at all four demand nodes shown is 0.20 m^3/s. Determine the flow in each pipe and the pressure head at each node.