Notes:

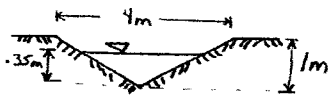
1. This examination consists of 5 pages (4 questions). Please ensure that your copy of the examination is complete. Bring any discrepancy to the attention of the instructor.
2. Answer **all** questions and show **all** calculations to ensure full marks. State and justify any necessary assumptions.
3. Duration of examination: 1 hour and 30 minutes
4. The point value of each question is indicated beside the question number.
5. This is an **open book** examination. Class notes and assignments are allowed. Hand-held calculators are permitted.

Question 1. (8 points: a = 1, b = 1, c = 1, d = 1, e = 1, f = 3).

a) Supercritical flow occurs in a rectangular channel. If there is a smooth, gradual, small decrease in channel width, will the water depth in the constricted section be smaller than, equal to, or greater than the upstream depth?

b) A 34 inch diameter culvert has a flow rate of 15.3 cfs. Estimate the critical depth in the culvert.

c) Water flows at a depth of 0.35 m in the following triangular channel. If the discharge is 0.3 m^3/s, determine whether the flow is subcritical, critical, or supercritical.
(Correct calculations required – correct guesses earn no marks)



d) True or False? Some stilling basin designs suggest that TW exceed d_2 by 10% in order to maximize the energy loss within the hydraulic jump.

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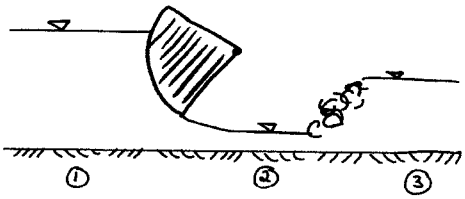
e) A sluice gate partially extends down into the flow within a rectangular channel. The upstream water depth is 10 ft and the downstream depth is 4 ft. The gate is suddenly opened high enough to cause a 45% increase in discharge under it.

i) Determine the initial specific discharge under the gate.

ii) Write out (but don't solve) the continuity and momentum equations that govern the surge travelling downstream. (Note: assume that the surge velocity **exceeds** the water velocity)

f) Water flows at steady state in a rectangular channel under a Tainter gate as shown. The positive x direction is to the right. The values of the momentum function at locations 1,2 and 3 are M1, M2 and M3, respectively. Similar naming conventions are used for the water depth (y) and the total energy (E) at each of the locations. Indicate which of the following is true by circling the correct answer.



Which of the following are true regarding the magnitude of the horizontal component of the force of the gate on the water (F_g):

a) $F_g = \gamma y_1^2 b - \gamma y_2^2 b$
b) $F_g > \gamma y_1^2 b - \gamma y_2^2 b$
c) $F_g < \gamma y_1^2 b - \gamma y_2^2 b$
d) none of the above

The alternate depth to y3 is:

a) greater than y2
b) less than y2
c) equal to y2
d) none of the above

Which of the following statements are true? (Note: there may be more than one!)

a) M1 > M3
b) M1 < M2
c) E2 < E3
d) M2 < M3
e) An increase in y_3 would cause the jump to move downstream.
f) An increase in y_3 would cause the jump to become somewhat submerged.
g) All of the above
h) None of the above

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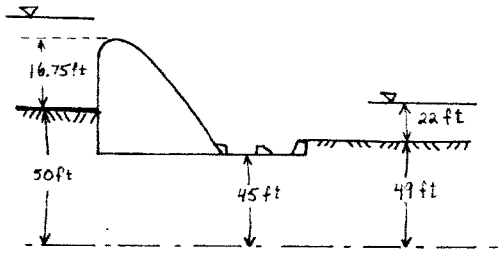
Question 2 (7 points)

An ogee spillway has been designed using a design total head of 25 ft. The abutment-to-abutment width is 900 ft. The abutments have a radius of $r = 0.25H_d$. There are 10 pointed-nosed piers across the crest, each with a width of 3 ft. The spillway height P = 16.75 ft. The downstream stilling basin and channel are both rectangular with widths of 900 ft. Relevant elevations with respect to an arbitrary datum are shown in the figure. The chute length is known to be roughly 3 times the hydraulic head. On a particular day the observed total head with respect to the spillway crest is 17.5 ft and the downstream water depth is 22 ft.

a) Determine the discharge.

b) Determine (ie. using calculations, rather than an educated guess) whether the hydraulic jump is somewhat drowned, stationary, or being swept out.



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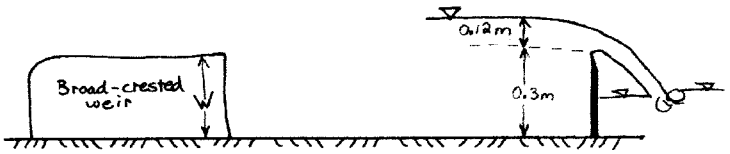
Question 3 (5 points)
A 0.89 m wide rectangular channel has a broad-crested weir followed by a suppressed sharp-crested rectangular weir. If the head, H above the sharp-crested weir crest is measured to be 0.12 m, what is the minimum value of W that will ensure unsubmerged flow conditions over the broad-crested weir?



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Question 4 (7 points)

Water flows through the rectangular channel shown below at a discharge of 30 m^3/s. The upstream depth is 3 m. The contraction and expansion energy losses are known to be 0.2 and 0.85 m, respectively. Determine the water depths within the contracted section as well as the downstream 10 m wide section. Draw and label a specific energy diagram (label all relevant points). Also, use the side view of the channel to draw an energy grade line for the transition.